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GRADY TRIPLETT
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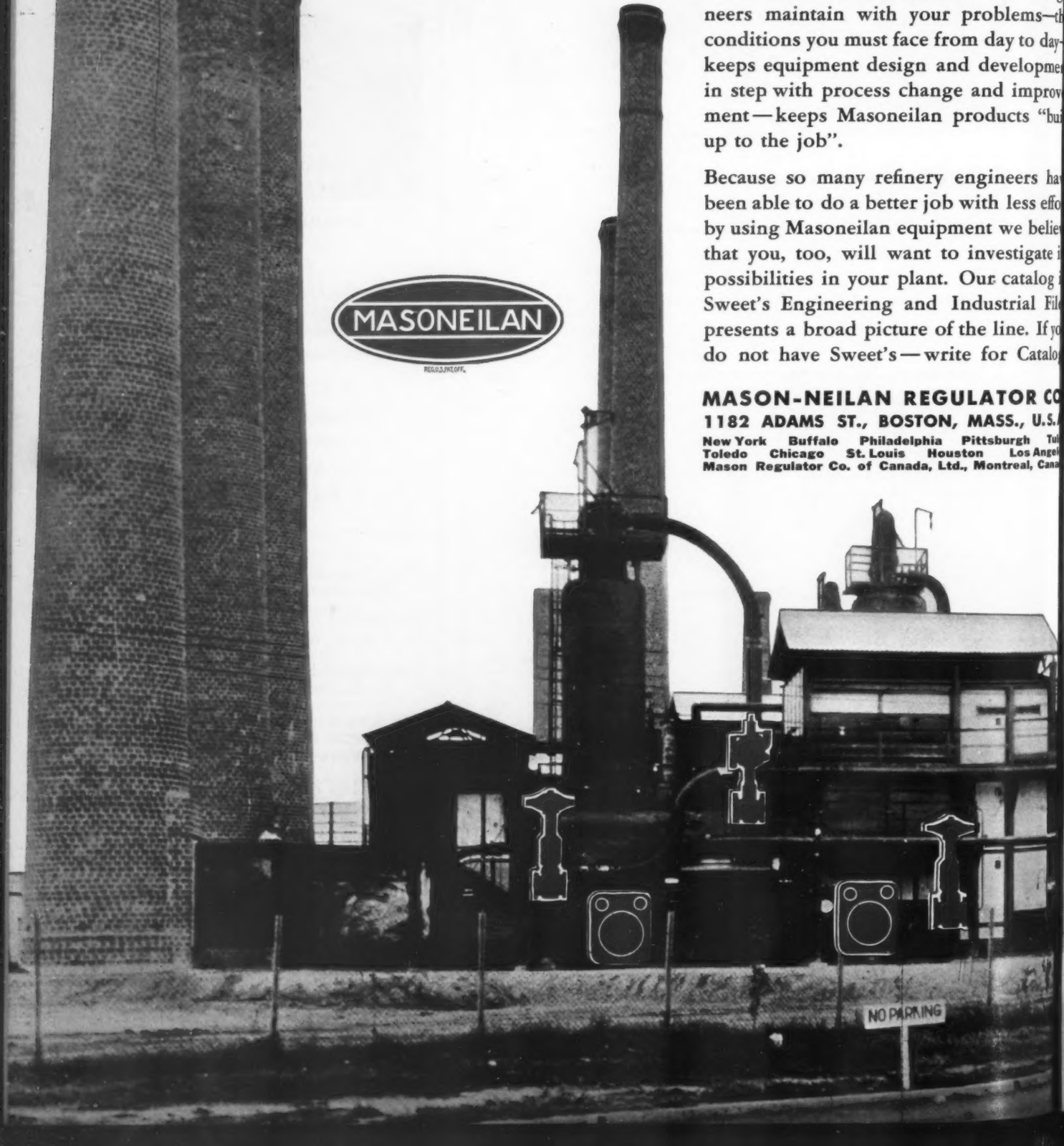


VOLUME 19, No. 9 SEPTEMBER, 1940

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

The Look Box

IT is the duty of each workman to protect his plant against sabotage. Along with that he faces the duty of making no groundless charges against fellow workmen.

If it is possible to keep fiercely alert and at the same time doubly restrained, the military preparedness period demands the combination. The need of the time was thus stated by J. A. Brown, president of Socony-Vacuum Oil Company, in a message to all employes:

Remain Sane and Be on the Alert

"This protection of property primarily depends upon the care and alertness of the employes. The employe should be on guard against any suspicious activity; he should refrain from gossip on products and processes; he should promptly report any defects in machinery, any mechanical interference with production, any accumulation of waste or rubbish that might constitute a fire hazard, anything which endangers the safety of his fellow employes or the company's operations. These precautions are not in the nature of 'spy hunts.' We all want to avoid hysteria and unjustified accusations. We simply want to do what we can to keep working conditions safe and productive."

Some of the advice of J. Edgar Hoover, of the Federal Bureau of Investigation, as to the methods of plant interference should be kept in mind, as:

"The expert saboteur discerns, usually through employment in a key plant, the particular buildings or the exact machinery vitally necessary to the continuance of production. Then he tries to halt or slow down that production."

CONFLICT between threatened court action against the petroleum industry, pending national legislation also with the petroleum industry in question, and objectives of the national defense council, which has demands to make on the petroleum industry, are a part of the confusion in Washington.

Legal, Legislative And Political

Correspondence between Senator Guy Gillette, of Iowa, and Truman Arnold, assistant attorney general, revealed this situation: The Iowa senator wrote to the effect that he had introduced a bill, seeking among other things to bring about segregation of integrated oil concerns, that the Department of Justice had investigated alleged violations of the Sherman act

and proposed prosecutions, whereupon hearings on the legislation were held up to be dove-tailed into court proceedings.

Recently the national defense council suggested that prosecutions be delayed since they might hamper the defense program.

The letter by Senator Gillette read:

"Unless you are able to give me controlling or satisfactory reasons to justify the neglect to conduct the prosecutions at this time, I shall probably feel impelled to reopen the hearings on the pending legislation . . . "

The reply by Assistant Attorney General Arnold had this:

"As a mater of courtesy to the defense commission and information to this department, the matter was referred for study as to possible effects on national defense. Their recommendations will be carefully considered with respect to modifying any of the relief sought in the oil suit, if, as a matter of fact, it appears that the interests of national defense are involved. This does not mean a waiver of the anti-trust laws. We anticipate no conflict.

"We are convinced that the oil suit will, in a civil proceeding, settle various issues which until now have been the subject of numerous criminal cases, all of which the department has won."

THE oratory and literature by which two political factions build to the climax of the November election will be filled with two words—capitalism and democracy. By their use, men will seek to prove that one is contrary to the other.

Two Words One Meaning

In reality, the two words do not conflict. When the privileges that come under capitalism are denied, there no longer will be democracy. Without property rights no civil rights can exist.

The fallacy of this reasoning has been well stated by Dr. Nicolas Murray Butler:

"There never has been such a thing as capitalism. That was a debating term coined by Karl Marx. Capitalism is not a principal. It is what the logicians call an accumulation. It is an accident, a by-product of successful labor, which has produced more than it spent. The principle is liberty, civil, political and economic—and the conflict is between liberty and compulsion. It is going on in every country in the world today and it is going on in this country."

So, when the demagogue rants of the evils of capitalism and promises to preserve democracy by destroying capitalism, he is in reality promising to preserve liberty by destroying liberty. He bases his promise on the proposition that there is fundamental difference between the privilege of using a billion dollars of savings for owning a corporation and the privilege of using a few dollars of savings to own a wheelbarrow. The two are identical, and the loss of one will be the loss of the other. When several thousand men and women are deprived of ownership of an automobile factory, a few million men and women will lose the privilege of owning automobiles, except by permission, which is compulsion.

Corporate ownership, which is branded as capitalism, ceased in both Russia and Germany, and shortly afterward individuals either had homes and farms confiscated or had to submit to limitations on how they could be used. Such is the present course of events in France.

American voters can create much confusion by asking those who make grandiose promises what is the difference between capitalism and democracy. The voting will be over long before men find a satisfactory answer.

IF industry is to fulfill its obligation in national defense, it must have the help of friendly government. Otherwise, apprehension will hold sway when concentration is essential.

Production Better Than Prosecution

The petroleum industry does not enjoy a consistent policy of government, and there are events to question the friendliness of the national administration. One is the threat of anti-trust legislation, a suit in prospect against more than 20 large oil companies and one trade association. Only recently some defendants in the Madison case met a reversal in the United States Supreme Court, which, some lawyers contend, previously had ruled to the contrary in litigation involving the coal industry. On the West Coast, oil concerns have ceased to contend against the federal government and will pay fines.

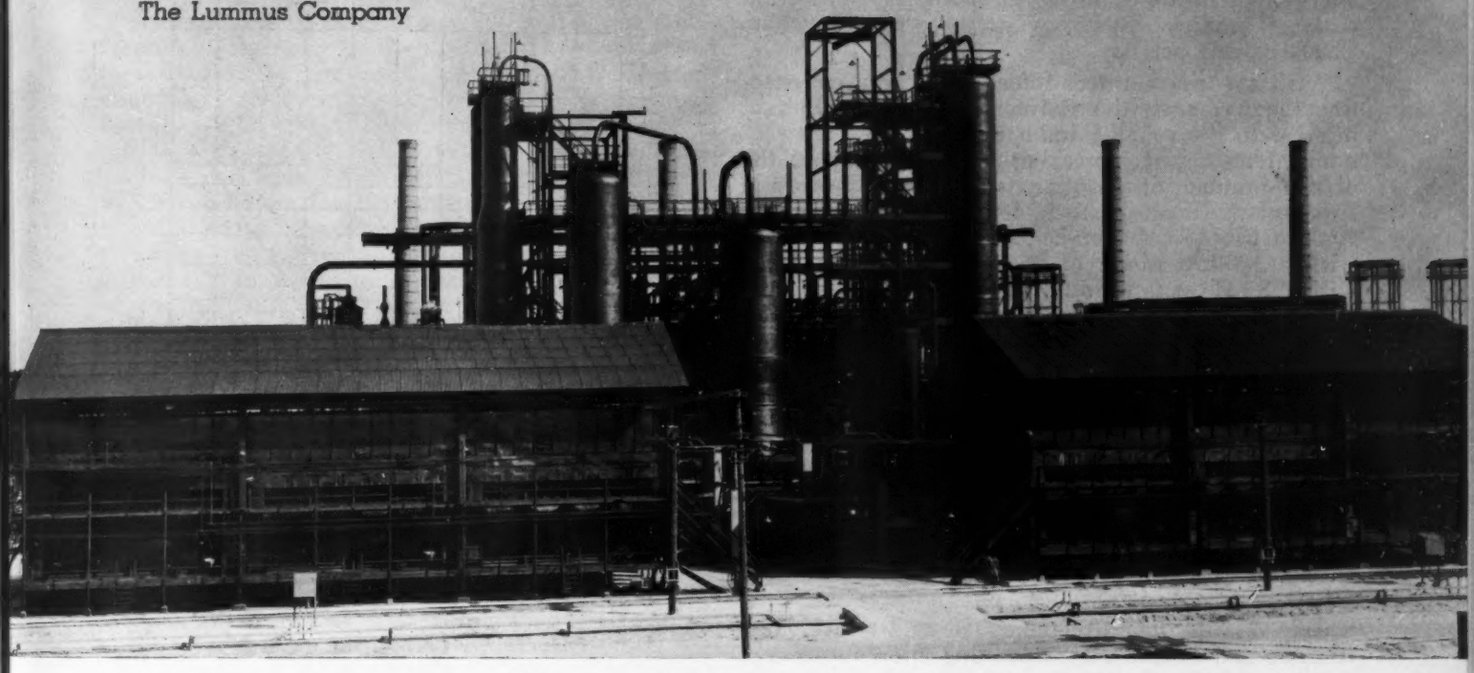
Frankly, the need of today is not prosecution of any industry. Instead, industry needs to be assured that the government is more interested in the materials of defense than it is in victories of the Department of Justice. Until there is a statement of policy and adherence to the policy, government will not have what it needs from industry and it will not have what industry can produce and for the most part is anxious to produce.

This attitude is taken in full knowledge of the possibility that violations of the law may exist. Prosecutions of the violations of the federal anti-trust laws can wait. Unless industry performs at its utmost, court room victories may be useless. And industry will do its utmost when it is not being harassed.

[*Continued on page 153*]

Gulf Polyform Process . . .

POVL OSTERGAARD,
Gulf Oil Corporation
and
DR. EUGENE R. SMOLEY,
The Lummus Company



Four-coil combination Polyform unit at Port Arthur refinery of Gulf Oil Corporation, handling 22,000 barrels of West Texas crude daily.

THE ever-increasing demand for more gasoline, and for higher octane number, has made it necessary for the oil industry to explore all possibilities for increasing the yield of gasoline from the crude from existing installations, and improving the yield and the quality of gasoline by new refining methods.

One of the recent accomplishments in the refining industry is the development of the Polyform process by the process division of the engineering, construction, and process department of Gulf Oil Corporation. The Polyform process differs from the ordinary thermal cracking process in that the oil is processed in admixture with varying amounts of normally gaseous hydrocarbons, particularly propanes and butanes, and in that the oil is subjected, in such admixture, to higher temperatures and higher

A NEW refining method, the Gulf Polyform process, is presented in this paper. This process combines in one operation the pyrolytic processing of oils to higher conversion per pass than is possible in an ordinary thermal unit with polymerization or refinery gases produced either from the oil undergoing conversion, or from an outside source. Flow sheets and photographs of naphtha Polyform, two-coil crude Polyform, and four-coil crude Polyform units are presented and discussed. The process produces high yields of high-octane gasoline possessing excellent distillation, lead susceptibility, blending and Research or Road octane appreciation characteristics from any type of charging stocks. Properties and treating of polyform distillates are presented. Specification aviation gasoline which will lead to 90 CFR-ASTM octane number with less than 3 cc TEL and 80 octane number CFR-ASTM unleaded safety fuel can be made from Polyform distillate.

Under patents of Gulf Oil Corporation and Phillips Petroleum Company, The Lummus Company now offers Polyform or Gas Reversion processes to the refining industry. The process has been in commercial operation for over four years with five units in Gulf Oil Corporation refineries, ranging from 1,500 to 22,000 barrels per day charge capacity. The Lummus Company is now building two large naphtha Polyform units with total production of 14,000 barrels per day of 76 CFR-ASTM octane number gasoline. The process, with investment costs and operating costs comparable to thermal cracking units and operating problems no more difficult, establishes itself as a practical, economical process for the production of high yields of 75-82 CFR-ASTM octane number gasoline from any type of naphtha charge and 72-74 CFR-ASTM octane number gasoline from any full crude, as well as a means of economically converting outside propanes and butanes along with naphtha into high yields of 76-82 CFR-ASTM octane number gasoline.

degrees of conversion per pass than would be possible, under otherwise similar conditions, without excessive coke formation in the cracking tubes. The process results in the production of gasoline in higher yield and of higher octane value than can be obtained by subjecting the same oil to a conventional thermal cracking operation.

The Polyform process has been used in large scale operation in the plants of the Gulf Oil Corporation for over four years with routine refinery runs of 1500 to 2500 hours on stream. At present, there are five polyform units in regular refinery operation with oil charge capacities ranging from 1500 to 22,000 barrels per day.

With the present trend for higher octane gasoline requirements, the Polyform process is of real interest to the refining industry as it offers an economical means of increasing yield and raising the octane number of gasoline from any refinery and any type of charging stock. It is possible to convert 20-30 CFR-ASTM octane number naphtha stock, with a boiling range of 250° to 450° F. to 76-82 CFR-ASTM octane number gasoline with high yields. From a whole crude, such as Mid-Continent, East Texas or West Texas, it is possible to obtain 3 to 4 percent higher overall gasoline yield of 72-74 CRF-ASTM octane number. The fuel gas produced varies from .70 to .85 specific gravity, free of butanes and containing only 2 to 15 percent propanes. Polyform gasolines have high octane numbers with road octane appreciation of from three to eight numbers, appreciation from CFR-ASTM octane to research octane of 9 to 14 numbers, high blending values, excellent distillation characteristics, and good lead susceptibility.

Clay treating and sweetening, or acid treating, rerunning and sweetening, depending upon sulfur content, are conventional. A small amount of gum inhibitor is added for gum stability.

By a modified operation, the naphtha Polyform process can be conducted to yield a distillate of approximately 80-84 octane number CFR-ASTM. This distillate has a very high aromatic content of from 20 to 35 percent, which is predominantly toluenes and xylenes. By cold acid treating and rerunning, this high octane Polyform distillate can be processed to yield approximately 40 percent of 77-79 octane CFR-ASTM aviation gasoline of satisfactory boiling range, acid heat and stability, which will lead up to 90 CFR-ASTM octane number with less than 3 cc. TEL. Besides the aviation gasoline cut, a 35 percent cut of aviation gasoline safety fuel with an octane number of 80 CFR-ASTM can be produced with properties as indicated later in the text. The balance of 25 percent is treating and polymer loss.

While the development of the Polyform process represents a distinct departure from prior practice, Polyform units are simple in design, and offer no greater operating problems than conventional thermal cracking units, as the plant equipment consists of pumps, heaters, fractionating towers, heat exchangers, etc., with all of which any cracking coil operator is thoroughly familiar. The instrumentation of these units allows complete automatic control of oil levels, pressures, temperatures, flow rates, etc., leaving to the operators supervision and fine adjustments for optimum results. Investment costs and utility requirements are only slightly higher than for conventional cracking units. The slightly higher costs are due to higher operating temperatures and pressures used in Polyform operations.

Polyform Theory

All oil cracking operations represent a compromise between yield and product quality. More drastic cracking of relatively heavy stocks tends to result in higher yields of gasoline while more drastic cracking of light stocks, such as naphtha, tends to

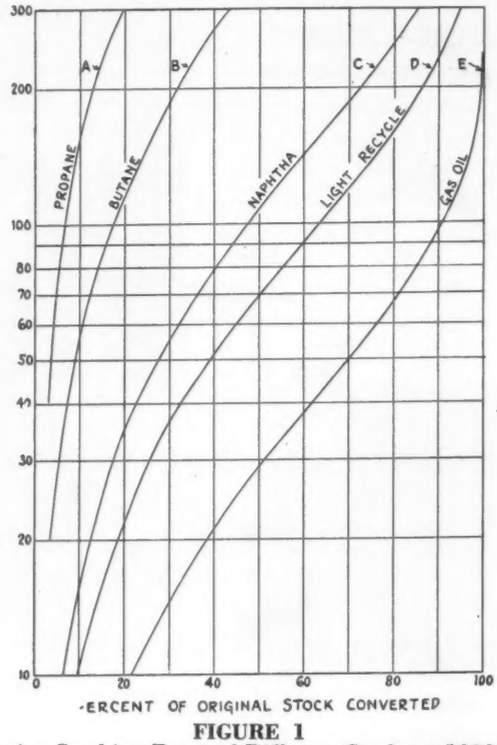


FIGURE 1
Relative Cracking Rates of Different Stocks at 1020° F.

reduce the yield of gasoline. It is known that the octane number of gasoline rises with the degree of conversion per pass, and that the reaction velocity of cracking rises sharply with temperature. More intense cracking ordinarily tends to increase the yield of normally gaseous hydrocarbons.

Inasmuch as the octane number or anti-knock value of the final cracked gasoline from any given stock is largely a function of the degree of conversion per pass, it is desirable to operate at as high a degree of conversion per pass as possible, providing the yield and quality in other respects of the gasoline product are satisfactory.

The yields and octane numbers which can be secured from any given cracking stock depend, to some extent, on the design of the still, but for any stock there is a definite crack-per-pass which cannot be exceeded without serious deposition of coke in the cracking coil, as any pressure still operator knows.

The ordinary thermal cracking process, therefore, has definite limitations in magnitude of yields and octane numbers obtainable.

Any process by which the crack-per-pass can be increased means higher octanes and greater yields of light products. The gasoline yield can be further increased by converting part of the gases produced to gasoline hydrocarbons. The Polyform process does exactly this.

Gaseous hydrocarbons, such as C_3 and C_4 hydro-

carbons are introduced to the polyforming coils with oils for two purposes:

1. In order to effect a higher degree of conversion of the oil when diluted with C_3 and C_4 hydrocarbons than is possible when this oil is cracked by itself.

2. For the purpose of simultaneous cracking of the oil to a higher degree of conversion than is possible when the oil is cracked by itself, and at the same time to effect a certain amount of cracking with subsequent polymerization and other side reactions of the C_3 and C_4 hydrocarbons and oils.

While it is true that there will always be a small amount of cracking of the C_3 and C_4 hydrocarbons in any case, the conversion per pass of these components at temperatures below 950° F. is so small that it may be said that the simultaneous cracking of the oil and polymerization of the C_3 and C_4 hydrocarbons can only be practically effected with oils which can be cracked at temperatures above 950° F. For oils which cannot be cracked at these high temperatures, the C_3 and C_4 hydrocarbons are primarily introduced in order to increase the crack-per-pass of the oil, and permit other side reactions. That favorable side reactions take place when Polyforming heavier oils is substantiated by the very large volume increase of products over charge, which is of the order of two to three times the volume increase encountered in thermal cracking.

With respect to heavy oils such as reduced crudes, heavy recycle oils, etc., there is a definite minimum percentage of C_3 and C_4 hydrocarbons in the total furnace feed which should be maintained in order to make possible the increase of the crack-per-pass of the oil. The minimum quantity of C_3 and C_4 hydrocarbons in the furnace feed is indicated to be related to the critical temperature of the furnace feed. It has been found that when cracking a mixture of an oil and C_3 and C_4 hydrocarbons at temperatures lower than the critical temperature corresponding to the mixture of the oil and the C_3 and C_4 hydrocarbons, this oil cannot be subjected to more severe cracking conditions than if the oil were cracked alone. This is attributed to the following.

When the temperature of an oil in a cracking tube is below the critical temperature of the oil and above its critical pressure there always exists a vapor phase and a liquid phase in the tube. The liquid phase is suspended in the vapor phase as minute oil particles which, due to the turbulence in the tube, are thrown out against the tube walls covering this with a thin oil film composed of the heavier components of the oil.

As the heat transmitted through the tube wall to the mixture of vapor and oil in the tube has to be transmitted through the oil film, the coking characteristics for this mixture are determined by the coking characteristics for the oil film in the tube. As long as this oil film exists, gas dilution of the oil will not make it possible to crack the oil to a more severe degree than if the oil were there by itself. However, as the percentage of C_3 and C_4 hydrocarbons in the furnace feed is increased we finally reach the point where the critical temperature of this mixture is equal to the temperature at which the oil can be cracked by itself. At this point only one phase exists, namely, a vapor phase. The oil vapors and the C_3 and C_4 hydrocarbon vapors will hence form a perfect solution and the film on the tube wall will be of the same composition as the composition of the main body of hydrocarbon vapors passing through the tube.

Before the right percentages of dilution are reached, there is no benefit in cracking the heavier oils in a dilution of normal gaseous hydrocarbons.

From the above discussion, it is evident that there exists an absolute minimum limit for C_3 and C_4 hydrocarbon dilution of a heavy oil in order to effect an increase in the cracking conditions to which this oil can be subjected. On the other hand, there is also a maximum limit for the dilution of any oil with C_3 and C_4 hydrocarbons, in this case determined from the cracking, polymerization, and other side reactions of the C_3 and C_4 hydrocarbons recycled with the oil.

Figure 1 indicates a plot showing the relative percentage of conversion of propane, butane, virgin straight-run Mid-Continent naphtha and light recycle gas oil when cracked at a temperature of 1020° F. and a pressure of 1000 pounds per square inch at different soaking times, expressed in seconds. The temperature of 1020° F. was arbitrarily selected to permit a comparison of these stocks. For naphtha polyforming, 1030° to 1130° F. is generally used.

From an inspection of Figure 1 it will be seen that by subjecting propane and butane and the straight-run naphtha to the same cracking conditions of 1020° F. and 1000 pounds pressure simultaneously with a soaking time of 150 seconds, the naphtha will be subjected to a conversion per pass of 60 percent while the butane at the same time will be subjected to a conversion per pass of 25 percent and the propane to a conversion per pass of 10 percent. If it is desired to reform the naphtha and at the same time crack and polymerize the C_3 and C_4 hydrocarbons, it is evident that it will be necessary to maintain a cycle ratio of butane circulating through the heating element to fresh butane introduced to or formed in the system of 4:1 and a cycle ratio of the propanes charged to the furnace over fresh propane introduced to or formed in the system of 10:1.

Likewise, if a less refractory oil as, for instance, virgin gas oil or light recycle stock, is to be cracked, and it is desired at the same time to crack and polymerize C_3 and C_4 hydrocarbons in the same coil it will be seen from Figure 1 that this will call for higher cycle ratios for the C_3 and C_4 hydrocarbons than if these gases are cracked in the presence of straight-run naphtha.

For instance, a light recycle stock like the oil represented by Curve D on Figure 1 can only be cracked to a conversion per pass of approximately 45 percent in C_3 and C_4 dilution without running into coking troubles.

Cracking this oil to 45 percent crack-per-pass at 1020° F. at 1000 pounds per square inch will call for a soaking time of 60 seconds. At the same time, the butane will be subjected to a conversion per pass of 10 percent and the propane to a conversion per pass of 4 percent, calling for cycle ratios between butane charged through the heating element and fresh butane introduced to or formed in the system of 10:1 and the corresponding cycle ratio for the propane of 25:1. These ratios may seem high, but are counterbalanced by the fact that heavier oils, when cracked, produce smaller percentages of total gas and hence also of C_3 and C_4 hydrocarbons than do naphthas, and the right cycle ratio of C_3 and C_4 hydrocarbons to oil furnace feed is usually obtained when the proper dilution for increased crack per pass is maintained.

From the foregoing it may be concluded that an

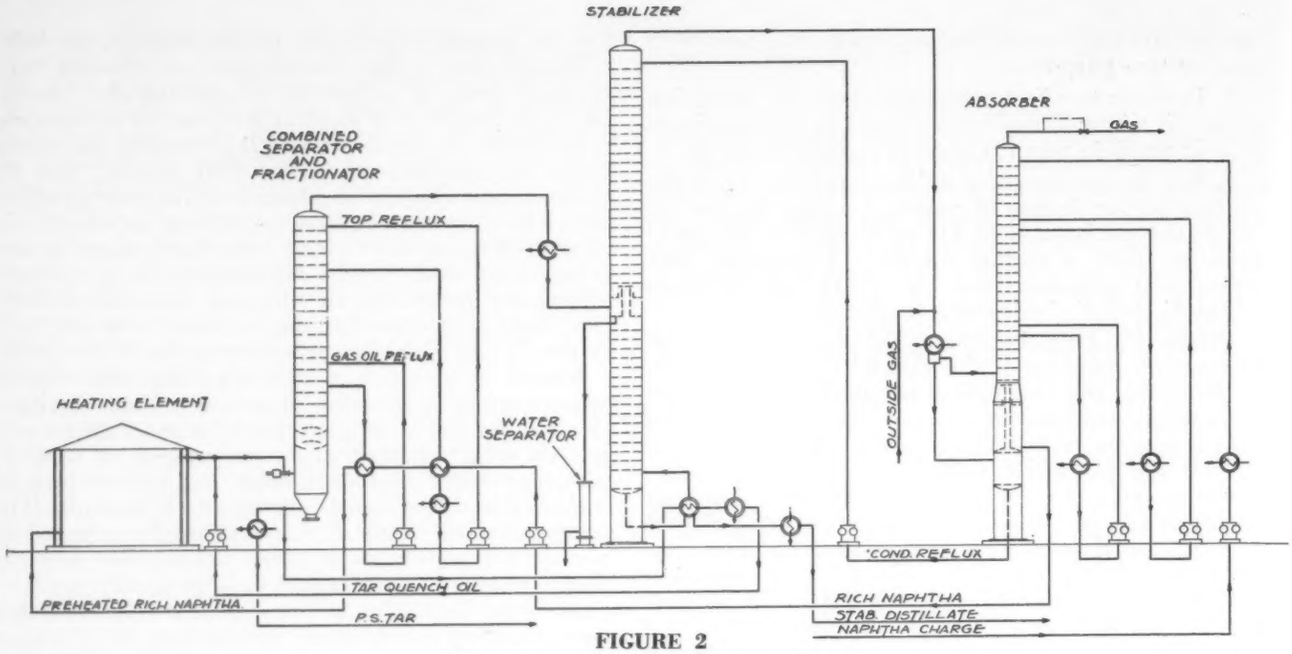


FIGURE 2
Flow Sheet—Naphtha Polyform Unit.

upper limit for the amount of C_3 and C_4 hydrocarbons which should be cycled through the heating coil with a certain oil when it is desired to completely crack and polymerize the C_3 and C_4 hydrocarbons can be exactly determined when the cracking characteristics of the oil are known and the amounts of C_3 and C_4 hydrocarbons charged to the system, or formed in the system, are known.

If there is introduced to the system not only an oil feed, but also a certain amount of C_3 and C_4 hydrocarbons from the outside and the conversion characteristics of the oil are known, it is easy to compute the cycle ratio which must be maintained for completely converting the C_3 and C_4 hydrocarbons introduced to the system from an outside source.

Generally speaking, the gasoline produced per pass for oils above heavy naphtha boiling range may be increased from 1.5 to 2 times the crack-per-pass obtained in an ordinary thermal cracking unit by employing the Polyform principle.

The tabulation in Table 1 shows a comparison between conversion per pass with ordinary thermal cracking and with the Polyform process.

Types of Polyform Units

To illustrate the flexibility of the Polyform process, the following descriptions of different types of Polyform units now in service are given with simplified flow diagram and typical yields. Figure 2 shows the simplest type of a once-through Polyform unit. This type of unit is particularly adapted for polyforming of naphthas, kerosene and light furnace oil, with simultaneous polymerization of C_3 and C_4 hydrocarbons from other cracking units. The unit consists of the same elements in any ordinary type of cracking unit, such as heater, separating and fractionating tower, stabilizer and absorber.

TABLE 1
Comparison of Crack Per Pass
(400 E. P. Gasoline By Volume)
Polyform vs. Conventional Thermal Cracking

PROPERTIES	Venezuela Reduced Crude		Mid Continent P.S. Stock		Venezuela Recycle Stock		Mid Continent Naphtha	
Gravity: °A.P.I.	19.3		26.0		27.1		50.0	
Assay Distillation Over Point: °F.	238		265		250		270	
10 percent at	496		451		424		302	
50 percent at	715		626		522		336	
90 percent at	1015		....		664		378	
Mol. Weight	284		270		201		125	
Characterization Factor	11.0		11.5		11.1		11.8	
Vol. percent Liq. Gas $C_3 + C_4$	None	25	None	53.8	None	44.2	None	49.2
Cracking Temp. °F	840	890	900	985	950	1000	1000	1030
Pressure Lbs./Sq. In. Ga.	500	600	200	750	500	1000	1100	1100
Max. Percent Gasoline/Pass	9.0	15	18	41.3	16.3	30.5	70.1	77.2
Octane No. Gasoline	64.0	68.0	65.0	70.0	72.0	78.0	71.7	75.1

This data from commercial units with 2,000 hour average length runs.

The cold naphtha charge is used for absorption oil in the absorber, which is equipped with sidestream coolers for removal of heat of absorption for full control of absorption, and to give desired gas circulation. The rich oil from the absorber constitutes the furnace charge. A second absorber, not shown on flow sheet, may be added using light gas oil reflux for absorption oil to extract the C_3 and C_4 hydrocarbons from outside gases charged to the unit. The second absorber is only necessary when outside gas feed contains large percentages of hydrocarbons lighter than propane, and it is not desired to boost the outside gases to the pressure in the naphtha absorber, as the gas oil absorber may be operated at lower pressures. Ordinarily, outside gases can be discharged directly into the naphtha absorber if in liquid phase or into vapor line between stabilizer and pre-condenser if in vapor phase.

Recirculated bottoms from the combined separating and fractionating tower is used for quench oil to the tube outlet ahead of the reducing valve in order to avoid coke formation in the transfer line and separating tower. The excess heat in the tar quench oil is usually sufficient for satisfactory reboiling of the Polyform distillate in the stabilizer. The combined naphtha and absorbed gas furnace charge is preheated to approximately 500° to 550° F. in trap-tray and gas-oil sidestream high pressure heat exchangers before entering the furnace. The furnace is usually designed with two chambers, one bringing up section and one soaking section, to permit full control of Polyform reactions.

Typical operating conditions for this type of unit are:

Back pressure on heating element..... 1000-1500 pounds per square inch
Tower pressure..... 300- 400 pounds per square inch
Outlet temperature from heater ..... 1020-1125° F.

Table 2 shows yields and inspections of the charge and products from naphtha polyforming without outside gas charge of (1) Eastern Venezuela naphtha 10 percent of crude, (2) West Texas straight-run gasoline 25 percent of crude, and (3) a 50-50 mixture of Pennsylvania and Mid-Continent naphthas. In this table are also given the yields and inspection of the charge and products from two naphtha Polyform units installed at the Gulf Oil Corporation's Pittsburgh and Cincinnati plants, charging, in addition to Mid-Continent naphtha, all of the gases from the balance of the refinery. These units are equipped with gas-oil absorbers operating at approximately 225 pounds per square inch pressure for the absorption of C_3 and C_4 hydrocarbons from the refinery gases. The gas oil is a sidestream reflux from the fractionating tower and the rich gas oil is refluxed back to the fractionating tower, in this manner introducing the C_3 and C_4 hydrocarbons in the outside gas to the units.

Figures 3 and 5 give complete yield-octane relationship from polyforming the Eastern Venezuela naphtha and the West Texas straight run gasoline

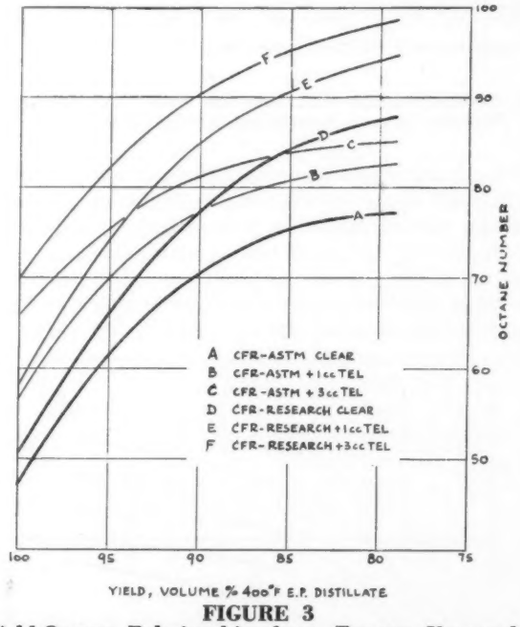


FIGURE 3
Yield-Octane Relationship from Eastern Venezuela Naphtha Polyforming.

for which inspections are given in Table 2. Curves showing TEL response with 1 cc. and 3 cc. of TEL per gallon of Polyform distillate are indicated on these plots.

Figure 4 contains plots showing volume percent yield of blends, clear, + 1 cc. TEL/gallon, and + 3 cc. TEL/gallon of clay-treated naphtha Polyform distillate and straight-run Venezuela gasolines at various degrees of polyforming the naphthas. The yields are indicated in percent of the 28.5 percent on the crude straight-run Eastern Venezuela gasoline with properties as shown in Table 3. This gasoline was reduced by removing 5 percent, 10 percent, and

TABLE 2

	Naphtha Polyforming			Naphtha Polyforming With Outside Gas Feed Charging	
	Eastern Venezuela Naphtha 18.6-28.5% on Crude	West Texas Straight Run Gasoline 25% on Crude	50-50 Mix MC & Pa. Naphtha 24-34% on Crude	50-50 Mix MC & Pa. Naphtha 24-34% on Crude	MC Naphtha 20-32% on Crude
YIELD DATA—VOLUME PERCENT OF NAPHTHA					
Charge:					
Naphtha	100.0	100.0	100.0	100.0	100.0
Outside Gas Feed, F.O.E.	.....	.....	.....	57.4	83.8
Total Charge	100.0	100.0	100.0	157.4	183.8
Products:					
Residue Gas, F.O.E.	9.0	14.3	15.1	59.0	80.7
Cracked Distillate	83.9	80.1	77.2	96.7	95.3
Residuum	7.4	2.6	7.8	9.7	9.2
Total Products	100.3	97.0	100.1	165.4	185.2
Outside Gas Feed, CF/B Chg.	None	None	None	2,090	2,820
Residue Gas CF/B Chg.	506	728	651	2,565	3,200
LABORATORY INSPECTION					
Naphtha:					
Gravity: °A.P.I.	47.9	58.2	50.8	49.2	50.2
Aniline Point: °F.	136	132	141	.....	137
Sulfur, L: percent	0.03	0.22	0.06	.....	0.04
Distillation, A.S.T.M. Over Point: °F.	266	96	206	219	156
End Point: °F.	431	415	433	451	494
10 percent at: °F.	290	170	300	290	244
50 percent at: °F.	311	266	345	342	345
90 percent at: °F.	372	374	395	412	439
Octane No.: CFR-ASTM, Clear	47.3	48.5	33.0	33.2	33.1
Stabilized Distillate:					
Gravity: °A.P.I.	52.0	57.8	56.7	56.0	59.2
Acid Heat: °F.	89	95	113	103	100
Aniline Point: °F.	71	81	70	83	91
Sulfur, L: percent	0.01	0.05	.....	.....	.....
Vapor Pres., 100 °F.: P.S.I.	8.2	9.7	11.5	10.1	11.1
Distillation, A.S.T.M.:					
Over Point: °F.	100	93	95	86	86
End Point: °F.	404	410	412	424	420
10 percent at: °F.	152	122	120	119	120
50 percent at: °F.	282	211	264	241	225
90 percent at: °F.	349	337	368	378	372
Octane No.: CFR-ASTM, Clear	76.1	75.9	75.1	76	76.5
Octane No.: CFR-Research, Clear	86.4	86.9	87.1	86.5	87.0
Residuum:					
Gravity: °A.P.I.	22.9	4.2	10.5	12.7	7.4
Viscosity, S.U.V.: 100 °F.	41	8140	75	75	3008
Sulfur, B: percent	0.13	0.16	.....	.....	0.1
Water and Sediment: percent	0.2	0.1	0.2	0.1	0.1
Outside Gas Feed:					
Podbielniak Analysis: Mol. %					
Hydrogen	.....	.....	.....	2.5	2.5
Methane	.....	.....	.....	37.4	34.9
Ethane	.....	.....	.....	20.4	18.8
Ethene	.....	.....	.....	2.2	3.5
Propane	.....	.....	.....	18.6	18.9
Propene	.....	.....	.....	7.5	8.5
Butanes	.....	.....	.....	5.0	6.7
Butenes	.....	.....	.....	4.0	4.8
Pentanes	.....	.....	.....	1.7	1.1
Hexanes and Heavier	.....	.....	.....	.....	0.3
Hydrogen Sulfide: Mol. %	.....	.....	.....	0.2	0.3
Total Unsaturates: Mol. %	.....	.....	.....	14.4	17.2
Specific Gravity, Air=1.0	.....	.....	.....	1.077	1.120
Residue Gas:					
Podbielniak Analysis: Mol. %					
Hydrogen	7.0	6.8	16.9	7.0	7.0
Methane	54.7	53.0	34.1	41.9	39.9
Ethane	25.6	26.4	26.7	23.9	24.2
Ethene	9.7	8.6	5.0	3.5	4.8
Propane	2.0	1.8	13.5	17.2	17.4
Propene	1.0	0.5	3.8	5.1	4.9
Butanes	.....	2.4	.....	0.9	1.0
Butenes	.....	.....	.....	0.5	0.8
Hydrogen Sulfide: Mol. %	.....	0.5	.....	0.2	0.3
Total Unsaturates: Mol. %	10.7	9.1	8.8	9.1	10.5
Specific Gravity, Air=1.0	0.700	0.770	0.86	0.906	0.935

TABLE 3
Properties of Various Percentages of Straight Run Gasolines and Naphthas from Eastern Venezuela Crude

Percentage on Crude	Total Gaso. 28.5	St. Run Gaso. 23.5	Naphtha 23.5 to 28.5	St. Run Gaso. 18.5	Naphtha 18.5 to 28.5	St. Run Gaso. 13.5	Naphtha 13.5 to 28.5
Gravity: °A.P.I.	60.5	64.6	45.7	68.5	47.9	72.8	50.8
Vapor Pressure at 100 °F.	9.6	....	....	....	....	15.2	....
Aniline Point: °F.	120	121	126	124	136	127	116
Acid Heat: °F.	3	4	3	5	2	7	2
Sulfur: percent	0.01	0.01	0.05	0.01	0.03	0.01	0.01
A.S.T.M. Distillation:							
Over Point: °F.	101	94	318	90	266	85	230
End Point: °F.	412	298	465	270	431	248	412
10 percent at: °F.	158	136	329	128	290	119	258
50 percent at: °F.	240	205	349	185	311	172	286
90 percent at: °F.	342	270	409	242	372	213	358
Octane Number, CFR-ASTM	59.9	64.3	40.9	67.0	47.3	71.1	49.7

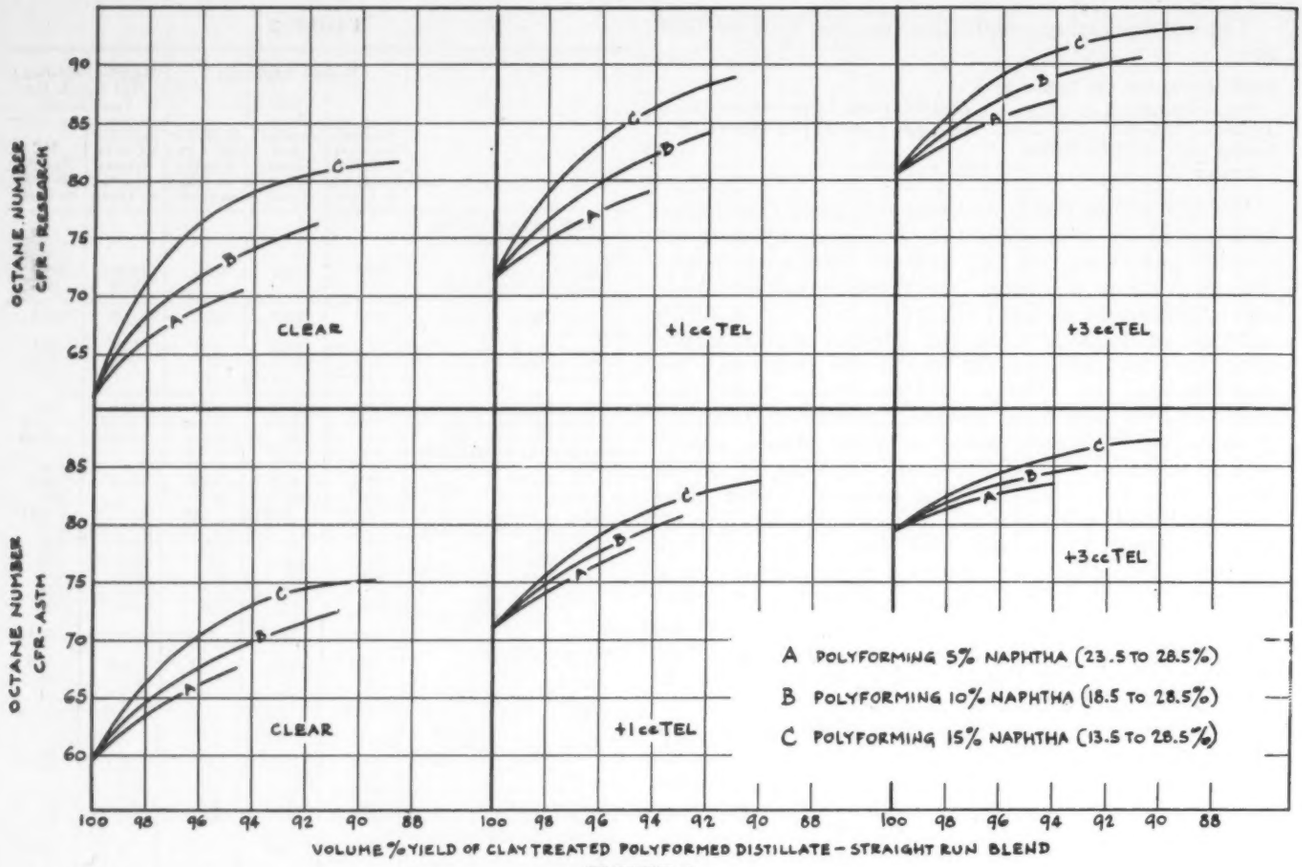

OCTANE NUMBER CFR-RESEARCH
OCTANE NUMBER CFR-ASTM
CLEAR
+1 cc TEL
+3 cc TEL
A POLYFORMING 5% NAPHTHA (23.5 TO 28.5%)
B POLYFORMING 10% NAPHTHA (18.5 TO 28.5%)
C POLYFORMING 15% NAPHTHA (13.5 TO 28.5%)
VOLUME % YIELD OF CLAY TREATED POLYFORMED DISTILLATE – STRAIGHT RUN BLEND

FIGURE 4

Yield-Octane Relationship of Blends of Varying Percentages of Undercut Straight Run Gasoline with Clay Treated Polyformed Complement Naphtha from an Original Charge of 28.5 Percent Eastern Venezuela Straight-Run Gasoline.

15 percent on crude of naphtha cuts with properties as shown on Table 3, which also shows inspections on the 23.5 percent, 18.5 percent, and 13.5 percent on crude of light gasoline cuts remaining after removal of the naphtha cuts. The naphtha cuts were polyformed to different octanes and blends prepared from the various naphtha polyformed distillates with corresponding straight-run gasolines. Figure 4 is very useful in working up economic balances to determine the most economical percentage of naphtha to polyform; it also shows clearly the large TEL

TABLE 4
Yield Data from Coking Section of Polyform Coking Unit

YIELD DATA	1	2	3	4	5
Charge—Volume Percent of Total Charge:					
Residuum from Vis-Breaking & Clean Oil Cracking	92.3	....	....	....	....
Residuum from Black and Clean Oil Cracking	....	88.6	....	....	....
Reduced Mid-Continent Crude	....	....	92.3	94.5	....
"A" Grade Asphalt from Mid-Continent Crude	....	....	....	....	91.7
Residuum from Naphtha Polyform Operation	7.7	11.4	7.7	5.5	8.3
Total Heavy Oil Charge to Coking Section	100.0	100.0	100.0	100.0	100.0
Products—Volume Percent of Total Crude					
Residue Gas	15.8	22.3	14.3	10.4	14.5
Polyformed Distillate	16.5	15.7	28.6	27.2	22.0
Gas Oil	41.5	28.6	45.0	50.3	44.8
Coke (400 Lbs./Bbl.)	29.1	33.0	15.6	15.4	22.4
Total Products	102.9	99.6	103.4	103.3	103.7
LABORATORY INSPECTION:					
Outside Heavy Oil Charge:					
Gravity: °A.P.I.	10.2	9.9	21.8	22.0	16.1
Viscosity, SUV at: 100 °F.	2,294	1,367	1,361	1,232	....
Viscosity, SUV at: 210 °F.	101	....	....	....	689
Pour: °F.	+20	+20	+40	+65	+60
Water and Sediment: percent	0.4	0.1	0.2	0.1	0.1
Conradson Carbon Residue: percent	11.3	8.6	4.6	4.6	8.4
Gas Oil Produced:					
Gravity: °A.P.I.	17.8	14.3	25.7	27.1	24.5
Pour: °F.	+20	+30	+35	+50	+40
Conradson Carbon Residue: percent	0.09	0.15	0.08	0.08	0.18
Aniline Point: °F.	82	60	135	143	121
Distillation, A.S.T.M.:					
Over Point: °F.	466	452	458	440	435
10 percent at: °F.	508	522	521	513	498
50 percent at: °F.	587	598	616	618	604
70 percent at: °F.	671	640	661	666	668
Coke:					
VCM: percent	10.8	9.7	13.1	9.0	10.8

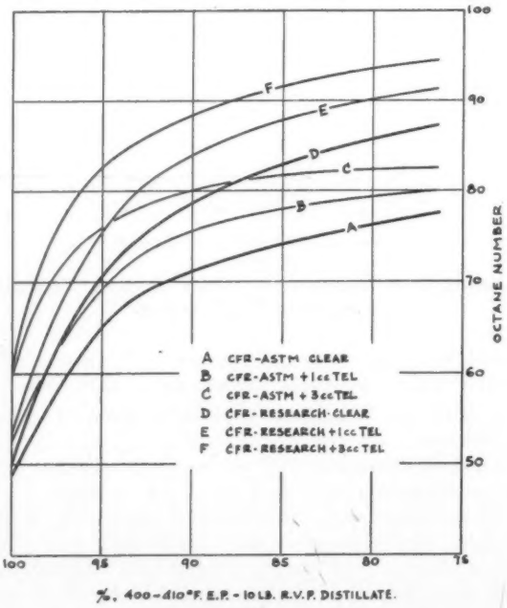

A CFR-ASTM CLEAR
B CFR-ASTM +1 cc TEL
C CFR-ASTM +3 cc TEL
D CFR-RESEARCH CLEAR
E CFR-RESEARCH +1 cc TEL
F CFR-RESEARCH +3 cc TEL
OCTANE NUMBER
%, 400-410°F. E.P. - 10 LB. R.V.P. DISTILLATE.

FIGURE 5

Yield-Octane Relationship from West Texas Straight-Run Gasoline Polyforming.

saving which may be obtained by the Polyform process at the expense of small reductions in total yield of gasoline.

There are at present three units of this type in service, which, besides polyforming naphtha, polymerize all residue gases from the balance of the refinery. Two units are under construction.

Two of the existing units are equipped with coking drums, into which the efflux from the furnaces is discharged. The stock to be coked, reduced crude or pressure still tar from other units, is introduced as quench oil to the transfer line at the furnace outlet. The tar is coked by means of waste heat in the furnace discharge. Reduced crude or tar of any gravity can be coked in this manner, or any heavy slop oil from the refinery can be converted to gasoline, coke and clean pressure still charging stock.

Typical yields from polyform coking different heavy charging stocks are shown in Table 4. The operations indicated in Table 4 were conducted to produce, in addition to gasoline and coke from the heavy stocks, a pressure still charging stock of approximately 750° F. end point suitable for cracking in ordinary thermal gas oil cracking units. This type of coking is very cheap as the only added operating expense is the cost of cleaning coke drums, and the overhead charges on coke drum installation. There are distinct advantages in coking a tar, low in hydrogen, in gas dilution, because of the low percentage of coke produced from Polyform coking.

A two-coil combination crude polyform unit flow is shown in Figure 6. In a unit of this type, when there is no straight run naphtha included in the charge, the next refractory stock, light recycle oil, is used for absorption oil in the absorber. The general flow, Figure 6, is as follows: Crude is preheated in exchangers and flashed into a topping tower, from which the desired straight-run products are removed. The hot reduced crude is charged direct to the vis-breaker furnace together with a heavy recycle sidestream from the separator. C_3 and C_4 condensate from condensation of stabilizer overhead is pumped through high-pressure exchangers into the vis-breaker furnace charge. The clean recycle stock from the base of the fractionating tower reboils the polyformed distillate in the stabilizer, preheats the rich recycle furnace charge, and is then cooled and pumped to the top of the absorber as absorption oil. The rich light recycle stream is pumped from the base of the absorber through high-pressure heat exchangers to the recycle Polyform coil.

In a unit of this type, very little cracking and polymerization of gases takes place in the vis-breaker coil. Practically all gas cracking and polymerization occurs in the recycle coil. Typical operating pressures and temperatures applied in Polyform vis-breaking heavy reduced crudes are listed below:

Back pressure of vis-breaker coil .... 400- 600 pounds per square inch
Back pressure of recycle coil .....1000-1200 pounds per square inch
Tower pressure ..... 300- 400 pounds per square inch
Outlet temp. of vis-breaker coil..... 900- 930° F.
Outlet temp. of recycle coil.....1000-1010° F.

By adding coke drums between the vis-breaker

TABLE 5
Yields and Products from Polyform Operation on Crude Oils

Charge	Heavy Venezuela Crude	West Texas Crude	West Texas Crude
Running For	Heavy Fuel Oil	Light Fuel Oil	Bunker C Fuel Oil
Thruput, B/Stream Day	5,000	5,000	22,000
Type Unit	Polyform	Polyform	Polyform
Polyform Coils:			
Reduced Crude	1	1	1
Recycle	1	1	1
Virgin Gas Oil	.....	.....	1
Naphtha	.....	.....	1
Yield Data: Vol. Percent of Crude:			
Gas, F.O.E.	4.9	3.9	11.5
St. Run Gasoline	8.8	29.6	13.1
Furnace Oil	2.2	4.2	0.6
Stabilized Polyformed Dist.	32.7	29.8	50.4
Fuel Oil	54.6	32.0	27.4
Total	103.2	99.5	103.0
Gas: CF/B Crude	239	192	420
CF/B Polyformed Dist.	733	644	835
LABORATORY INSPECTIONS:			
Crude:			
Gravity: °A.P.I.	17.9	34.3	34.4
Viscosity, SUV at 100 °F.	1026	45	43
Sulfur, B: percent	1.92	1.50	1.57
Water and Sediment: percent	0.5	0.1	0.2
Distillation:			
Over Point: °F.	198	124	130
Percent at 392 °F.	8	31	30
Percent at 700 °F.	65	76	.....
10 Percent at: °F.	431	240	235
50 percent at: °F.	682	554	560
Stabilized Polyformed Dist:			
Gravity: °A.P.I.	55.5	58.0	56.7
Sulfur, L: percent	0.39	0.44	0.24
Acid Heat: °F.	112	114	121
Aniline Point: °F.	88	88	.....
Octane No., CFR-ASTM	74.9	74.8	73.3
Vapor Pressure, 100 °F.: P.S.I.	11.2	9.5	9.6
Distillation:			
Over Point: °F.	82	88	95
End Point: °F.	422	422	418
10 Percent at: °F.	132	127	136
50 Percent at: °F.	269	253	242
90 Percent at: °F.	392	382	372
Fuel Oil:			
Gravity: °A.P.I.	5.1	12.0	7.1
Viscosity, Furol at 122 °F.	1546	84	215
Sulfur, B: percent	2.9	2.0	2.06
Water and Sediment: percent	0.1	0.2	0.5
Pour: °F.	55	20	35
Residue Gas:			
Specific Gravity (Air=1.0)	0.819	0.837	0.838
Podbielniak Analysis:			
Methane and Hydrogen: Mol. percent	55.9	54.2	51.4
Ethane and Ethylene	32.8	33.4	34.3
Propane and Propylene	10.2	11.3	13.0
Butanes and Heavier	1.1	1.1	1.3
Total Unsaturates	6.4	5.6	5.4

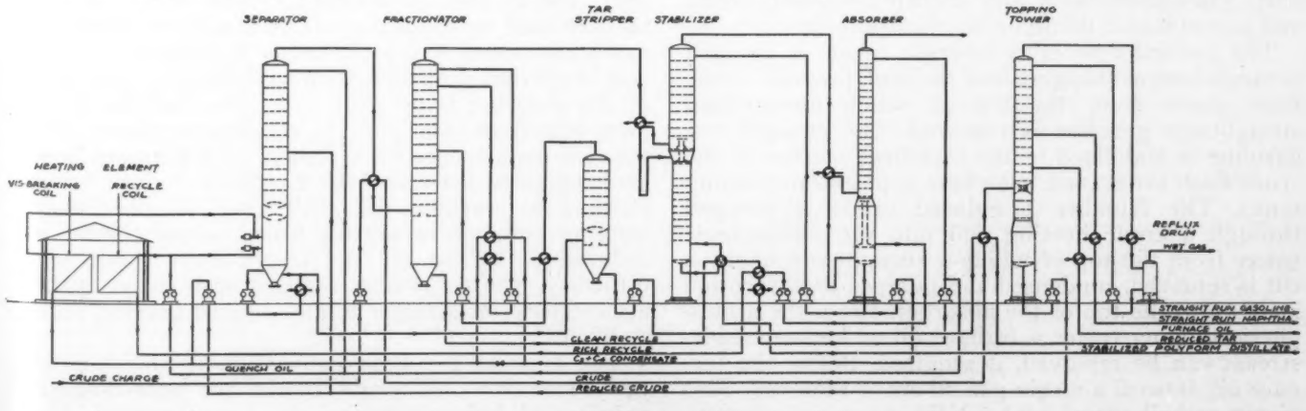


FIGURE 6
Flow Sheet—Two-Coil Combination Crude Polyform Unit.

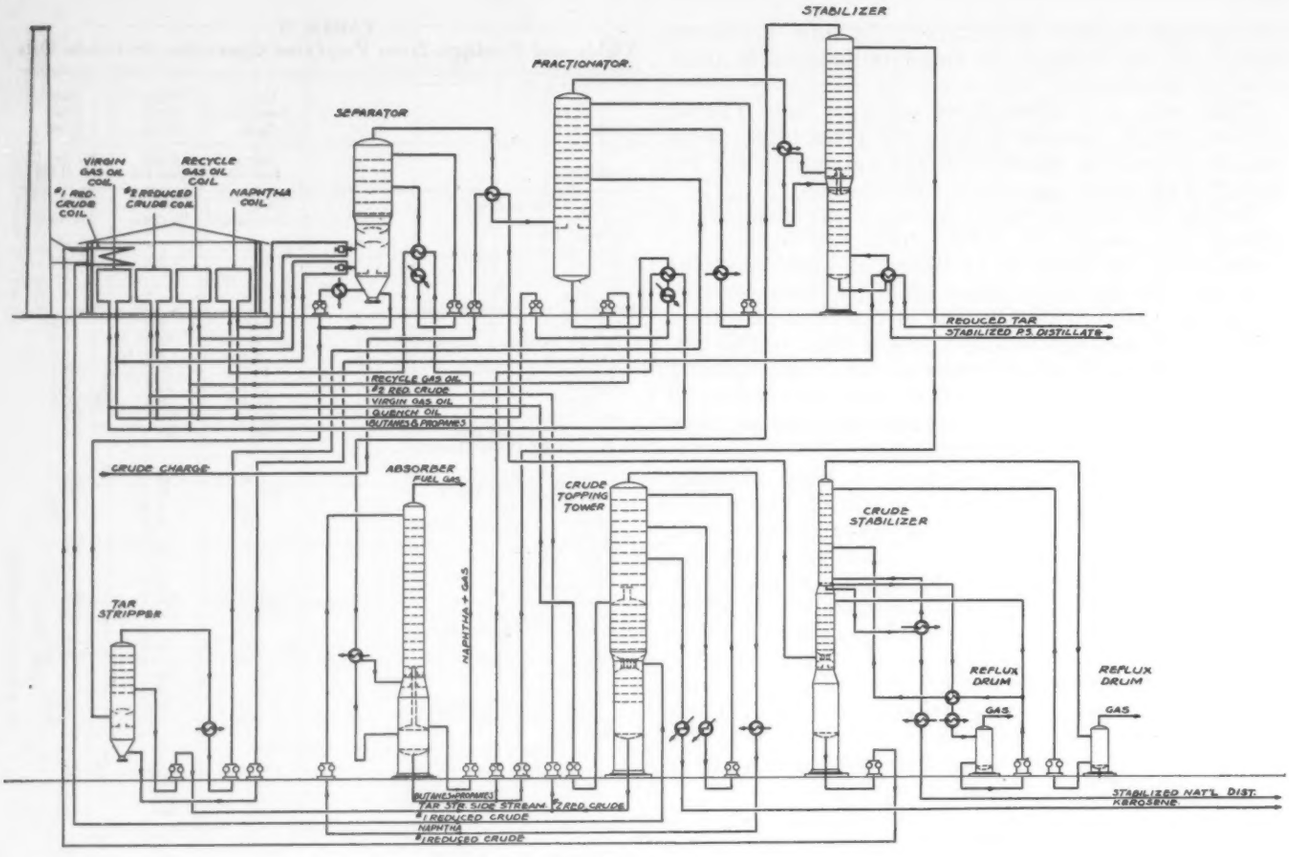


FIGURE 7
Flow Sheet—Four-Coil Combination Crude Polyform Unit.

furnace and the separating tower the vis-breaker charge may be once-through coked with a marked increase in polyformed gasoline yield. Table 5 shows yields from Polyform vis-breaking of 17.9° A.P.I. Venezuela crude and Polyform vis-breaking of 34.3° A.P.I. gravity West Texas crude.

Four-Coil Combination Crude Polyform Unit

Figure 7 is a simplified flow sheet of a 22,000 barrels per day crude topping and Polyform unit at the Gulf Oil Corporation's Port Arthur plant. The only products from this unit are stabilized straight-run gasoline, stabilized polyformed distillate, Bunker "C" fuel oil and dry gas of .78 to .84 specific gravity. In one unit it replaces the conventional type of combination units, thermal or catalytic polymerization unit, gas compression and absorption plant, crude and pressure still distillate stabilization plants.

The general flow is as follows: Crude is charged through heat exchangers into the high pressure crude flash tower from the top of which unstabilized straight-run gasoline is removed. The straight run gasoline is stabilized in the stabilizer section of the crude flash tower, and from here is passed to running tanks. The Number 1 reduced crude is pumped through a crude heating coil into the atmospheric tower from the top of which a straight-run naphtha cut is removed, condensed and pumped as absorption medium to the top of the absorber. From the atmospheric topping tower a furnace oil or kerosene sidestream can be removed, if required. Below the furnace oil drawoff a virgin gas oil cut is removed. This virgin gas oil cut of 1.0-1.5 NPA color and approximately 700° F. end point is charged hot to the virgin gas oil polyform coil with its allocated C_3 and C_4 diluent. In this coil, the gas oil is polyformed once-through to between 35-45 percent gasoline production per pass.

From the bottom of the atmospheric tower the Number 2 heavy reduced crude is charged hot through the polyform vis-breaker coil together with the heavy tar stripper sidestream and required C_3 and C_4 diluent. A conversion per pass of approximately 14 to 16 percent is obtained in this coil. The light recycle stock from the base of the fractionating tower of approximately 1.5 NPA color and 700 end point is likewise charged hot to the recycle polyform coil with the proper C_3 and C_4 dilution. The light recycle stock is subjected to a conversion per pass (gasoline produced) of approximately 25 to 32 percent. The C_3 and C_4 diluent for these three coils is all furnished as condensate from stabilizer overhead and is composed of approximately 25 percent butanes and 75 percent propanes. Rich naphtha from the base of the absorber is polyformed in the naphtha polyform coil. Both the C_3 and C_4 condensate diluent and the rich naphtha are preheated in high pressure heat exchangers to between 550° to 620° F. before being charged to cracking coils. All four coils discharge into one common separating tower, where the tar is reduced to 10° to 12° A.P.I. gravity without any difficulty. The tar is later reduced with steam in the atmospheric tar stripper to any desired gravity, such as 2° A.P.I.

The type of pyrolytic conversion in this unit is truly selective. All virgin stocks are once-through polyformed before entering the tower system. For this reason, the recycle stock is a real recycle oil,

TABLE 6
Comparison of CFR-ASTM., CFR-Research, and CFR-Uniontown 1937 Road Octane Numbers of Polyform Gasolines and Straight Run Gasoline Blends

Description of Gasoline	OCTANE NUMBER			C.F.R.—UNIONTOWN—1937 ROAD OCTANE NUMBER				
	C.F.R. A.S.T.M.	C.F.R. Research	Research Minus A.S.T.M.	Chevrolet	Ford	Plymouth	Average	Road Minus A.S.T.M.
Naphtha Polyform	75.1	85.0	+ 9.9	79.7	79.1	78.8	79.2	+4.1
Naphtha Polyform with outside Gases	76.1	87.2	+11.1	82.3	....	....	....	+6.3
Mixture—48 percent Pa. St. Run + 52 percent Naphtha Poly	70.0	74.5	+ 4.5	....	....	....	72.0	+2.0
West Texas Polyform	73.6	84.2	+10.6	77.0	77.3	77.2	77.2	+3.6
Mixture of West Texas St. Run & West Texas Polyform	70.8	73.6	+ 3.1	75.0	74.3	74.8	74.7	+4.2

highly refractory, with aniline point of 30 to 35, as compared with 150 for virgin gas oil and 75 to 80 aniline point for recycle stock from thermal cracking units. Typical operating pressures and temperatures for this unit are as follows:

Back pressure on naphtha coil .....1000-1200 pounds per square inch
Back pressure on recycle coil .....1000-1200 pounds per square inch
Back pressure on virgin gas oil coil.. 500- 600 pounds per square inch
Back pressure on red. crude coil..... 500- 600 pounds per square inch
Tower pressures ..... 350- 400 pounds per square inch
Outlet temperature of naphtha coil.....1060-1070° F.
Outlet temperature of recycle coil.....1000-1010° F.
Outlet temperature of virg. gas oil coil... 995-1000° F.
Outlet temperature of red. crude coil..... 915- 930° F.

Typical yields when charging a 34.4° A.P.I. West Texas crude are shown in Table 5. Figure 9 shows a comparison of octane numbers and TEL susceptibility of polyformed and thermal cracked gasolines from West Texas crude.

Properties of Polyform Gasoline

Octane Number—The octane number of Polyform gasoline depends, like the octane number of all other cracked gasolines, to some extent on the characteristics of the charging stocks. In general, the highest CFR-ASTM octane number can be obtained from a naphthenic charging stock of low sulfur content and the lowest octane number from a paraffinic stock, and from high sulfur stocks. However, in naphtha polyforming, it is always possible to produce a gasoline with an octane number, CFR-ASTM, of 75 to 77, regardless of the characteristics of the charging stock.

This is illustrated in Table 2, which gives the yields and inspections on charge and products from from three different types of naphtha charging stocks of different boiling ranges, sulfur content, and octane numbers. It should be noted that the CFR-ASTM octane number of the Polyform distillate from the three charging stocks are very close, varying between 75.1 for the distillate from Mid-Continent-Pennsylvania naphtha mixture, and 76.1 from the Eastern Venezuela naphtha, while the Research octane number of the Mid-Continent-Pennsylvania distillate is the highest, 87 against 86.4 for the distillate from the Eastern Venezuela naphtha. This can be explained when comparing the CFR-Research octanes with the yields from the various stocks. The yield of 83.9 percent from the Eastern Venezuela naphtha is the highest, while the yield from the Mid-Continent-Pennsylvania naphtha of 77.2 percent is the lowest, indicating a more severe conversion of the Mid-Continent-Pennsylvania naphtha.

Polyform gasoline is characterized by having a very much higher appreciation between CFR-ASTM octane ratings and CFR-Research octane ratings than ordinary thermal-cracked gasoline. The spread between the ASTM and Research octane numbers of an ordinary thermal cracked gasoline is of the

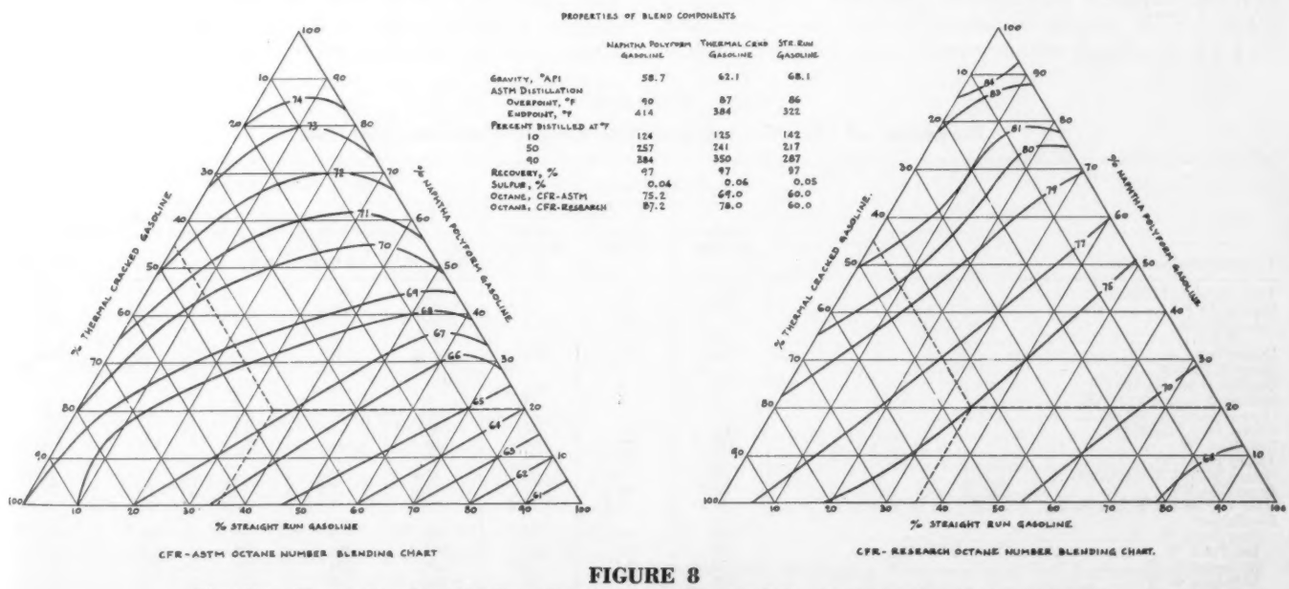

PROPERTIES OF BLEND COMPONENTS
NAPHTHA POLYFORM GASOLINE
THERMAL CRKD GASOLINE
STR. RUN GASOLINE
GRAVITY, °API 58.7 62.1 68.1
ASTM DISTILLATION
OVERPOINT, °F 90 87 86
ENDPOINT, °F 414 384 322
PERCENT DISTILLED AT °F
10 124 125 142
50 257 241 217
90 384 350 287
RECOVERY, % 97 97 97
SULFUR, % 0.04 0.06 0.05
OCTANE, CFR-ASTM 75.2 69.0 60.0
OCTANE, CFR-RESEARCH 87.2 78.0 60.0
% THERMAL CRACKED GASOLINE
% NAPHTHA POLYFORM GASOLINE
% STRAIGHT RUN GASOLINE
CFR-ASTM OCTANE NUMBER BLENDING CHART
CFR-RESEARCH OCTANE NUMBER BLENDING CHART.

FIGURE 8
Blending Charts for Straight-Run Gasoline and Thermal-Cracked Gasoline from Gas Oil with Naphtha Polyform Gasoline.

order of 5 to 9, while the spread for a polyformed gasoline is of the order of 9 to 14.

The appreciation of road octane number above the CFR-ASTM octane number is better for the polyform gasoline than for an ordinary thermal cracked gasoline from the same stock.

Table 6 shows a comparison between CFR-ASTM, CFR-Research, and CFR-Uniontown 1937 Road Octane numbers of various polyformed gasolines and blends of these gasolines with straight run gasolines.

Blending Value—Polyform gasolines have excellent blending values in blends of straight-run gasolines and naphthas, as indicated in Table 7. The blending value of Polyform gasoline with thermal cracked gasoline of 68-70 octane number, CFR-ASTM is practically the same as the clear octane number; the octane number of the blend being close to the arithmetic mean of the octane number of the components.

Figure 8 presents two three-coordinate blending charts, with CFR-ASTM and CFR-Research octane numbers, for blends of (1) straight-run gasoline, (2) thermal-cracked gasoline from gas oil cracking, and (3) naphtha polyformed gasoline, all stocks of Mid-Continent origin. The inspections of these stocks follow:

	Straight Run Gasoline	Thermal Cracked Gasoline	Naphtha Polyformed Gasoline
Gravity: °A.P.I.	68.1	62.1	61.1
ASTM Distillation			
Over Point, °F.	86	87	86
End Point, °F.	322	384	402
10% at, °F.	142	125	130
50% at, °F.	217	241	244
90% at, °F.	287	350	352
Recovery, percent	97.0	97.0	97.0
Acid Heat, °F.	6	172	151
Percent Sulfur	0.05	0.06	0.05
Octane Number, CFR-ASTM	60	69	75.2
CFR-Research	60	78	87.2

To illustrate the use of these charts, lines are indicated for a blend of 35 percent straight run gasoline, 45 percent thermal-cracked gasoline, and 20 percent naphtha polyformed gasoline, showing 67.2 CFR-ASTM octane number on the one chart and 75 CFR-Research octane number on the other. These

TABLE 7

Blending Value of 76.5 CFR-ASTM Octane No. Polyform Distillate in A5 Reference Fuel

Blend No.	1	2	3	4	5
Percent Polyform Distillate in Blend	5	15	25	50	75
Percent A5 Reference Fuel in Blend	95	85	75	50	25
CFR-ASTM Octane No. of Blend	43.5	48.1	52.6	62.1	70.0
Calculated CFR-ASTM Octane No. Blending Valve of Polyform Distillate	102.0	92.0	89.2	83.8	79.8

Blending Value of 76.5 CFR-ASTM Octane No. Polyform Distillate in 51.5° A.P.I. Mid-Continent Naphtha

Blend No.	1	2	3	4	5	6
Percent Polyform Dist. in Blend	5	10	20	30	40	50
Percent 51.5 °A.P.I. M.C. Naphtha in Blend	95	90	80	70	60	50
CFR-ASTM Octane No. of Blend	39.7	42.3	48.9	52.0	56.9	61.9
Calculated CFR-ASTM, Octane No.: Blending Valve of Polyform Dist.	110	109	100	89	88	87

charts show the high blending value of a polyformed distillate in the run-of-plant gasoline from a northern refinery.

Lead Susceptibility—The lead susceptibility of Polyform gasolines for the same starting octane number compares very closely to thermal-cracked gasolines and is influenced similarly by sulfur content. Figures 3 and 5—yield-octane relationship from Eastern Venezuelan naphtha and West Texas straight run gasoline polyforming—show the lead susceptibility of these gasolines. Figure 9 shows a comparison of lead susceptibility of Polyform and thermal-cracked gasolines from West Texas crude. From this plot it should be noted that it takes 1.2 cc. per gallon of TEL, corresponding to approximately 13 cents per barrel of gasoline to lead the ordinary thermal cracked gasoline to the same CFR-Research octane number as the polyformed distillate.

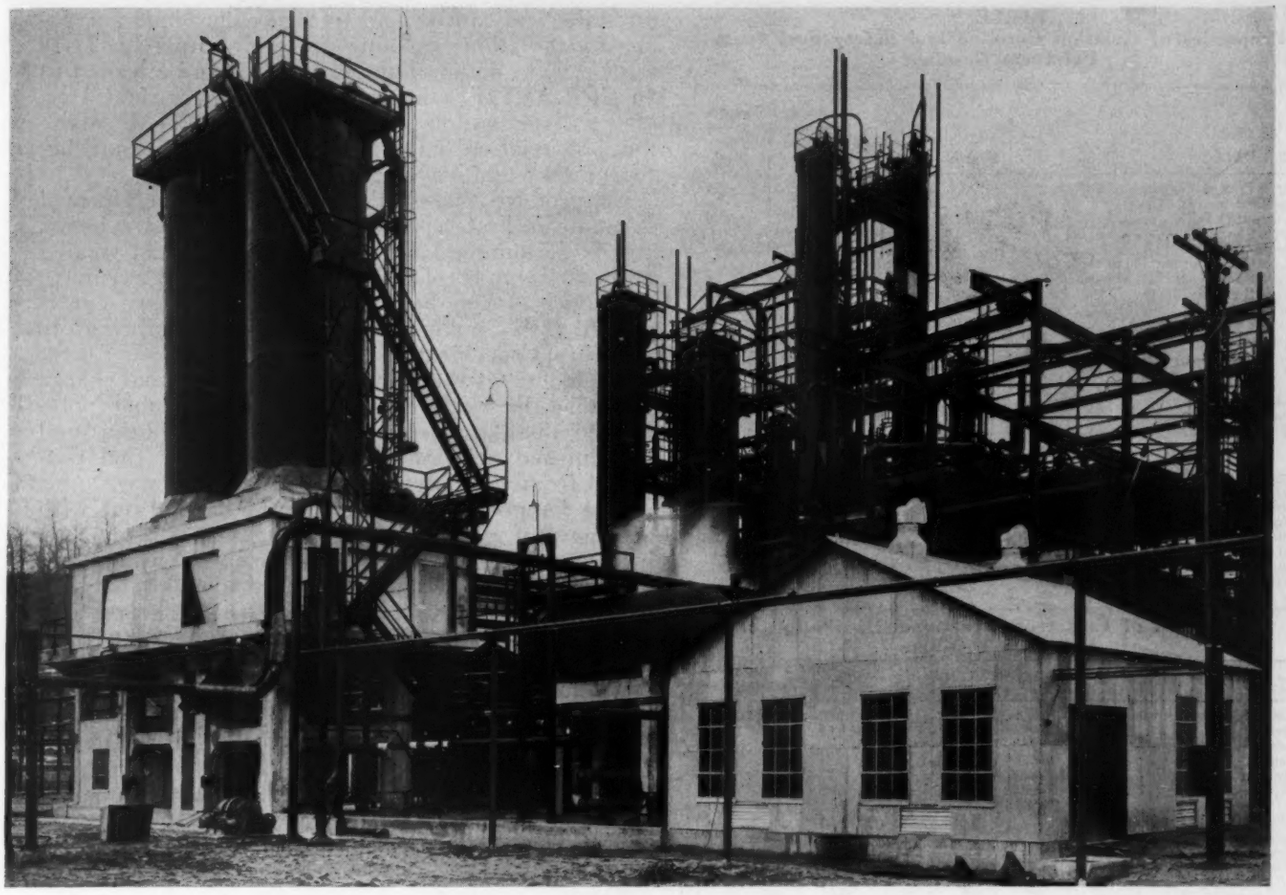
Treating of Polyform Distillate

The treating of Polyform distillates is no different than the treating of conventional thermal-cracked distillates and presents no added problems. Polyform gasoline made from sweet naphtha or crude may be cut directly off the unit and blended into a final colored gasoline after the addition of gum inhibitor. For use in water-white gasoline blends, Polyform distillate from sweet naphtha or crude may be clay treated with a production of 3000

TABLE 8

Porperties of Clay Treated and Acid Treated Polyform Gasolines

	M. C. NAPHTHA		WEST TEXAS CRUDE				
				Caustic Washed, Acid Treated, Doctor Sweetened Distillate of Various End Points from Raw Distillate			
Polyform Gasoline From:	Raw Distillate	Clay Treated	Raw Distillate	300 E. P.	325 E. P.	350 E. P.	375 E. P.	400 E. P.
Yield: Percent of Charge	100	97	100	58.1	65.1	77.2	84.5	90.6
Gravity: °A.P.I.	58.4	59.8	56.7	68.1	65.3	61.3	60.3	57.9
Color: Saybolt	....	+30	+ 6	+30	+30	+30	+27	+25
N.P.A.	1.0	....	....	....	....	....	....	....
Doctor Test	Bad	Poor	Bad	Good	Good	Good	Good	Good
Sulfur: L Percent	.05	.03	.24	.05	.07	.08	.09	.10
Cu. Dish Gum: Mg/100 CC	118	9	....	....	....	....	....	....
Preformed Gum: Mg/100 CC	4	4	17	1	2	3	3	3
Oxygen Gum: Mg/100 CC	....	....	....	67	55	181	44	140
Oxygen Stab. Min/210 °F	+45	+30	195	45	75	30	75	135
Acid Heat: °F	120	98	121	146	142	132	134	116
Aniline Point: °F	85	92	....	....	....	....	....	....
Octane No. C.F.R.—A.S.T.M.	75.8	76.5	73.3	75.9	75.4	74.8	73.8	73.2
Octane No. L-3	79.8	80.1	....	77.9	77.0	76.6	75.8	75.3
Reid V. P. at 100 °F. Lbs./Sq. In.	10.9	11.4	9.6	12.9	11.7	10.9	10.1	9.8
Distillation:								
Over Point: °F	88	82	95	94	96	98	100	100
End Point: °F	416	415	418	302	326	348	375	395
10 Percent at: °F	122	119	136	118	124	130	136	139
50 Percent at: °F	226	224	242	184	196	216	230	240
90 Percent at: °F	374	372	372	260	282	308	334	351
Recovery: Percent	96	96	97	96	96	97	97	97



Naphtha Polyform unit with coke drums, Cincinnati refinery, charging 2800 barrels Mid-Continent naphtha, 1900 barrels propane and butane and 2400 barrels vis-broken tar daily.

to 5000 barrels per ton of clay and resulting in a distillate of +30 color, an increase in CFR-ASTM octane of 0.5 to 0.75 number, a decrease in acid heat, and an increase in gum inhibitor response. Table 8 shows the inspections before and after clay treating polyformed Mid-Continent naphtha distillate.

Polyform distillate of over 0.1 percent sulfur from a sour naphtha or crude may be cold acid-treated with two to five pounds per barrel of acid for reduction of sulfur to specifications followed by rerunning to end point, sweetening and gum inhibiting. The octane number drops from 0.0 to 0.5 CFR-ASTM, depending upon the original sulfur content and the extent of sulfur reduction. Table 8 shows the inspections on raw West Texas polyformed distillate and inspections on different gasolines with end point from 300° to 400° F. produced from the raw distillate by acid treating, rerunning and sweetening.

Polyform gasoline may be sweetened by any accepted sweetening method, such as doctor sweetening, lead sulphide sweetening, etc.

Aviation Gasoline from Polyform Distillate

With modified operating conditions, a Polyform unit can be adjusted to produce a distillate with an octane number CFR-ASTM of from 80 to 84. A distillate of this type may be produced from any type of stock, but preferred stocks are gasolines, naphthas, kerosene and light furnace oils.

The 80-84 octane Polyform distillate is highly

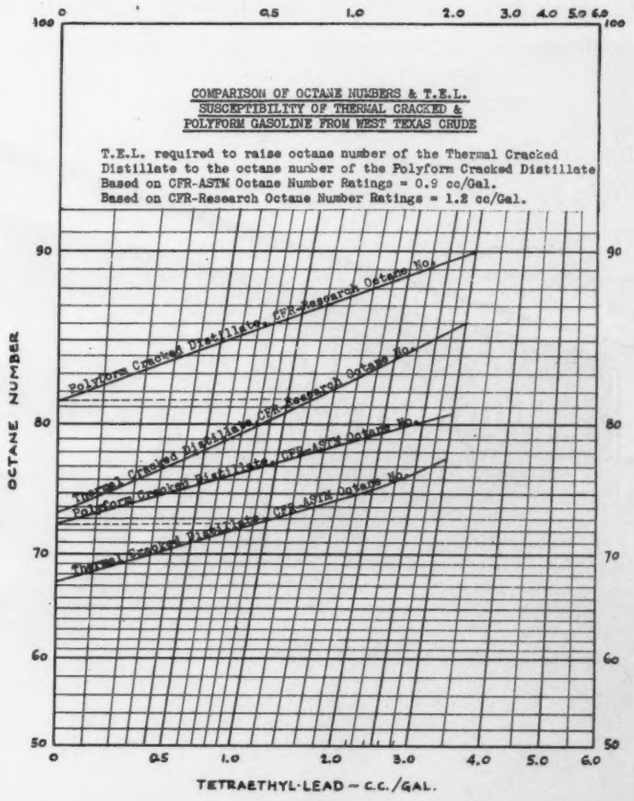


FIGURE 9
Comparison of Octane Numbers and T.E.L. Susceptibility of Thermal-Cracked and Polyform Gasoline from West Texas Crude.

TABLE 9
Properties of Aviation Gasoline and Safety Fuel from Polyform Gasoline

YIELD DATA	Naphtha	Polyformed Distillate	Finished Products: Aviation Gasoline	Finished Products: Safety Fuel
Volume Percent Polyformed Distillate	....	100.0	39.2	35.3
Inspection:				
Gravity: °A.P.I.	47.5	49.8	55.8	36.2
Sulfur, L: percent	0.05	0.04	0.011	0.018
Freezing Point: °F	....	....	....	Bel.-76
Copper Dish Gum: Mg/100 cc	....	187	1	....
Oxygen Stability, 212 °F.: Minutes	....	105	300+	....
Oxygen Gum: Mg/100 cc	....	219	1	....
Acid Heat: °F	2	68	10	2
Aromatic Content: Percent				
Benzene	....	4.4	....	....
Toluene	....	10.7	....	....
Xylene	....	11.6	....	....
Total	....	26.7	....	....
Aniline Point: °F	136	37.1	....	....
Octane No.: CFR-ASTM	47	82	77	80
+ 1 cc TEL/Gal.	57	86	84	86
2	....	88	88	87
3	66	90	90	88
Vapor Pressure, 100 °F.: P.S.I.	....	10.0	6.2	....
Distillation, A.S.T.M.:				
Over Point: °F	266	86	114	301
End Point: °F	431	448	307	426
10 percent at: °F	290	139	156	311
20 percent at: °F	296	....	170	314
50 percent at: °F	311	245	205	326
90 percent at: °F	372	362	250	372

Inspection of Cuts from Fractional Distillation of Polyform Distillate

CUT No.	1	2	3	4	Bottoms	Loss
Yield: Percent by Volume	20.5	20.5	20.4	18.9	16.0	3.7
Gravity: °A.P.I.	78.5	54.7	44.4	38.8	30.2	..
Aromatic Content: Percent						
Benzene	3.2	11.8	7.0	....	....	..
Toluene	2.0	10.5	24.8	8.7	....	..
Xylene	....	3.8	14.5	34.8	1.9	..
Total	5.2	26.1	46.3	43.5	1.9	..
Aniline Point: °F	....	51	26.3	11.3	....	..
Distillation, A.S.T.M.						
Over Point: °F	71	132	196	248	324	..
End Point: °F	263	312	328	364	436	..
10 percent at: °F	77	157	212	265	336	..
50 percent at: °F	117	182	233	285	355	..
90 percent at: °F	188	227	272	322	396	..

aromatic and can be acid treated to produce a satisfactory aviation gasoline of approximately 77-79 CFR-ASTM octane number, which can be leaded to 90 CFR-ASTM octane number with less than 3 cc. of TEL per gallon, and an 80 CFR-ASTM octane number aviation safety fuel with boiling range between 300° and 425° F.

To produce these aviation fuels, the polyformed distillate is first separated into a light and a heavy cut by rerunning. The light cut is cold acid treated with 20 pounds of 98 percent acid and rerun to aviation gasoline boiling range. The heavy cut is treated with 5 pounds of 98 percent acid and rerun to safety fuel specifications.

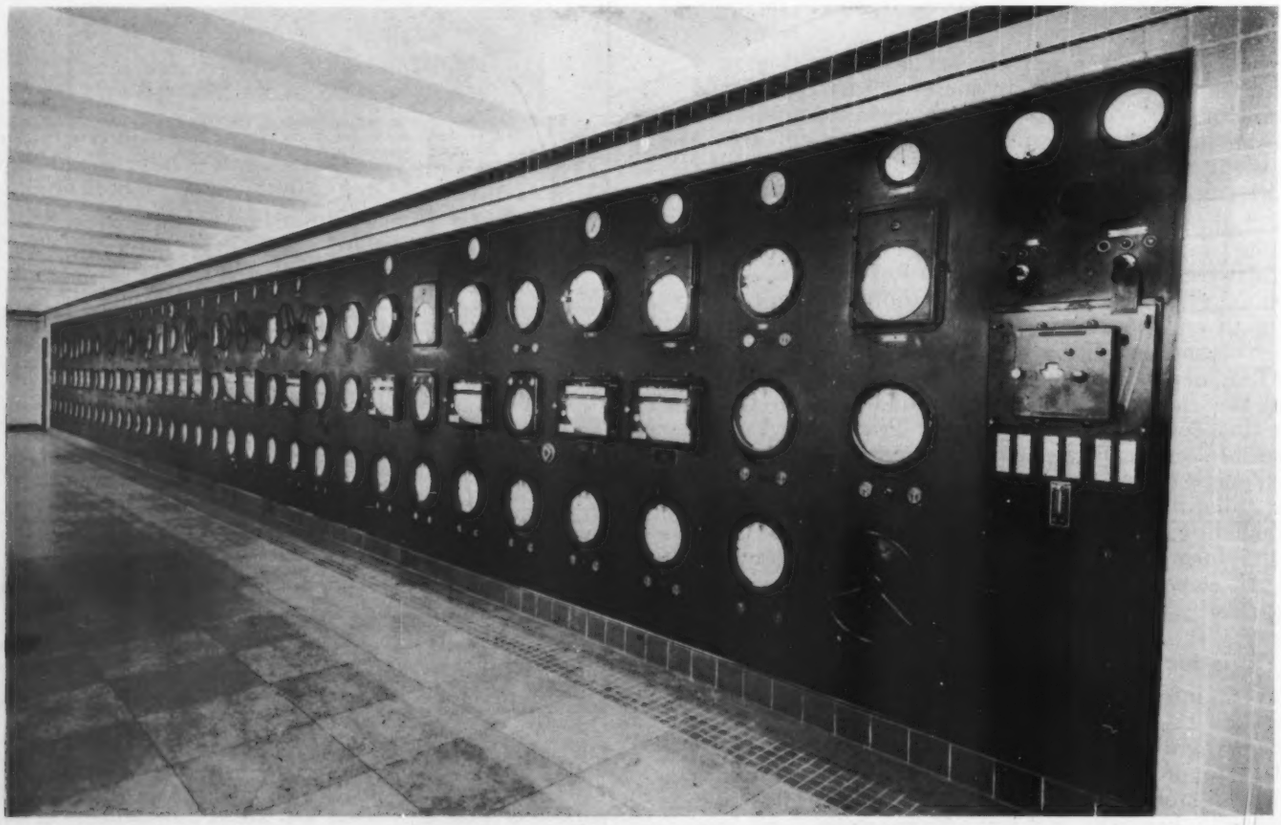
Table 9 gives the inspections of the original charge naphtha, the 82 CFR-ASTM octane number polyformed distillate produced from this naphtha, and the finished aviation gasoline and safety fuel produced from the polyformed distillate.

The foregoing operation may be carried out with a somewhat modified flow arrangement to yield an increased amount of aviation gasoline without the simultaneous production of safety fuel.

It will be noted from Table 9 that the aromatic content of the 82 octane polyformed distillate, particularly toluenes and xylenes, is high and that these fractions may be readily concentrated by distillation.

Further information on the Gas Reversion and Polyform processes, as practiced by the Phillips Petroleum Company and the Gulf Oil Corporation, will be presented later jointly by these companies and The Lummus Company.

Due credit is given the operating personnel, laboratories and technical staff of Gulf Oil Corporation for the analytical and operating data recorded in this paper.



Control board, 22,000-barrel combination West Texas Crude Polyform unit.

Process Development Section

IN SELECTING the pages for the Process Development Section of REFINER AND NATURAL GASOLINE MANUFACTURER for 1940, the effort has been made to present those either new to the industry or those in which material changes in either flow diagram or description amount to substantial revision since last year. Thus the section becomes something of a record of progress in refining and natural gasoline manufacture for the past year. Accordingly, the section does not offer many processes, some of which are more widely used than those presented.

The section is in effect a supplement to the PROCESS HANDBOOK for 1940, a more complete compilation of the various methods of converting both crude oil and natural gas into finished products. The handbook, also published by Gulf Publishing Company, is available at $1.50 a copy. It contains valuable engineering tables as well as an extensive list of processes.

In keeping with the current trend in refining, catalysis leads in the processes offered. This trend began several years ago. Indications are that it will hold a place at the forefront of refining for several more years. Catalytic advances are now evident in treating, or chemical refining. In this objectionable materials are removed from material and at the same time the treating improves one or more characteristics of the product.

Information on the following pages came from several sources. In most instances it was prepared either by the holder of the patent or by the concern privileged to license the process. In all instances it was prepared especially for presentation in REFINER AND NATURAL GASOLINE MANUFACTURER and its affiliated handbook. Only by such cooperation could REFINER AND NATURAL GASOLINE MANUFACTURER present the information to the industry. The pages are fully copyrighted and reproduction is not permissible by merely giving credit to the publisher. Should reproduction be desired, permission must be had either through the publisher or through the holder of the patent.

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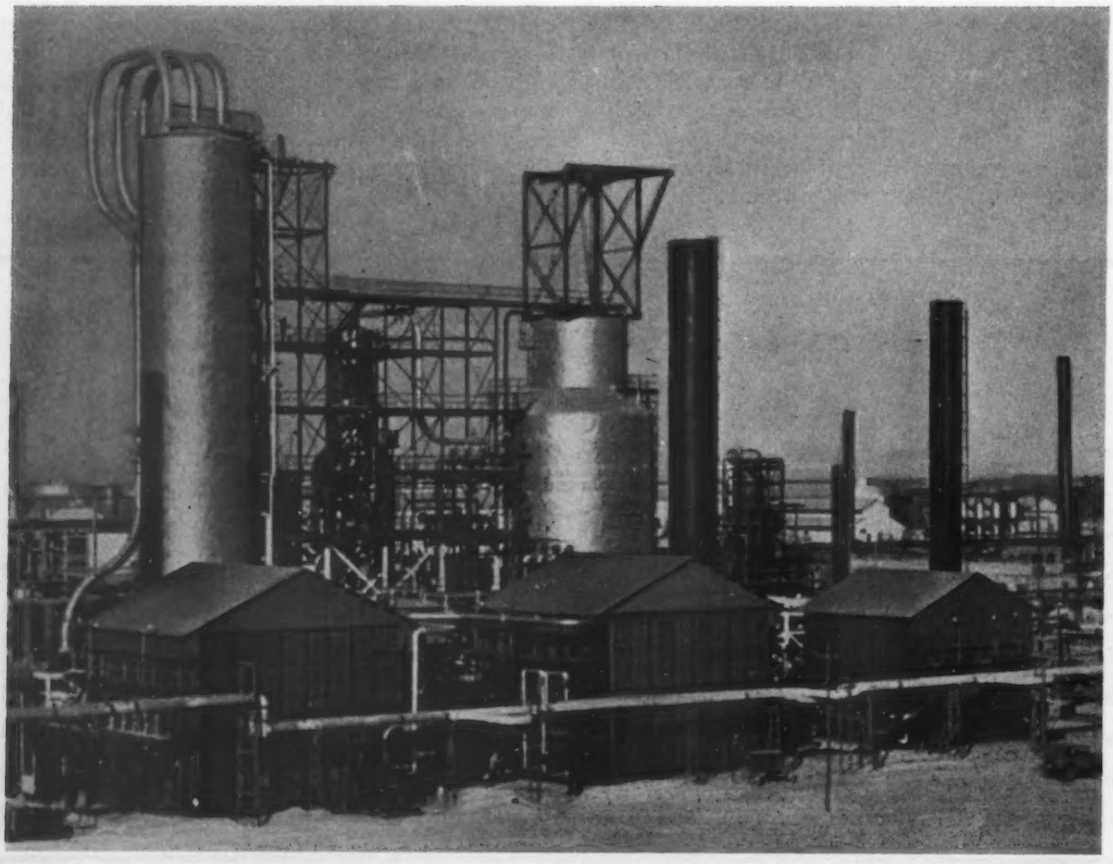
Badger Distillation Processes

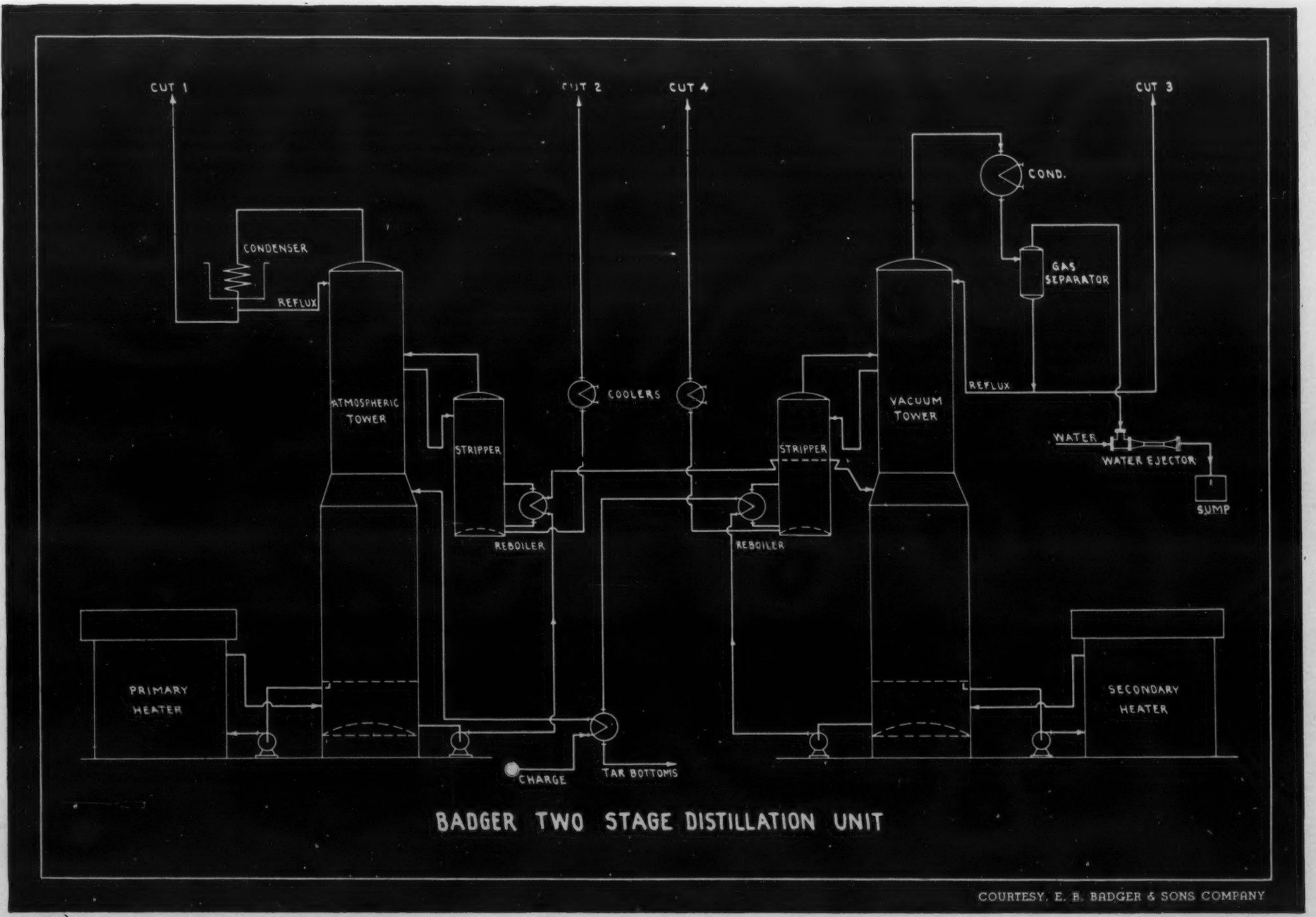
AMONG the many topping, vacuum and special distillation units engineered and constructed by E. B. Badger & Sons Company over the past fifteen years, several are noteworthy on account of their size or the sharpness of separations made or for some new feature in design.

The unit shown in the picture is the largest distillation unit in the world. Three such units have been put into operation at the Abadan refinery of the Anglo-Iranian Oil Company, each with a capacity of 90,000 barrels per day. The practicability of such large units has been fully demonstrated and their economy both as to capital and operating costs is definitely proven.

Another large unit designed for obtaining sharply cut narrow fractions from a heavy crude has recently been completed. It was particularly desired that the non-recoverable steam used in this unit should be reduced to a minimum. Reboiling was used instead of steam stripping and vacuum was maintained by a water ejector. The main features of the unit are shown on the flow diagram. A.S.T.M. distillations of typical fractions obtained are shown in the table below:

	TEST NUMBER 1				TEST NUMBER 2			
	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 3	Cut 4
I. B. P.	106	312	396	510	95	257	399	502
10 percent	166	322	417	520	127	277	426	520
50 percent	220	333	435	530	171	307	437	536
90 percent	266	357	464	549	206	352	461	568
Dry Point	283	...	...	...	225	369	475	595
End Point	293	375	482	568	232	374	478	597




CUT 1
CUT 2
CUT 4
CUT 3
CONDENSER
REFLUX
ATMOSPHERIC TOWER
STRIPPER
COOLERS
REBOILER
STRIPPER
REBOILER
VACUUM TOWER
COND.
GAS SEPARATOR
REFLUX
WATER
WATER EJECTOR
SUMP
PRIMARY HEATER
SECONDARY HEATER
CHARGE
TAR BOTTOMS
BADGER TWO STAGE DISTILLATION UNIT
COURTESY, E. B. BADGER & SONS COMPANY

Bari-Sol Process

THE Bari-Sol process of centrifugal dewaxing has been so named for the reason that it makes use of solvents which are heavier than either the oil to be treated or the wax to be separated therefrom. The process and the special type of centrifugals employed were developed in U.S.A. by The Sharples Corporation, Philadelphia, Pa., and Max B. Miller & Co., Inc., New York, N. Y., and in Europe by the Separator-Nobel Company, Stockholm, Sweden. By an agreement made in 1936 patent rights and technical information were mutually exchanged, and the sale of the process and centrifugals is handled in North America, Japan and Russia exclusively by The Sharples Corporation and Max B. Miller & Co., Inc., and in the rest of the world by the Separator-Nobel Company.

A solvent which is sufficiently heavy to cause the wax to be lighter than the oil solution allows the wax to be withdrawn from the center of the centrifugal rotor by mechanical means as an alternative to the use of naphtha as a solvent which throws the wax to the outer surface of the rotor where a carrier liquid is used to control the continuous discharge of the wax. In consequence, a centrifugal operation employing a heavy solvent permits the centrifugal dewaxing of lubricating oil stocks of any character irrespective of the crystallinity of the wax contained in the oil.

The Bari-Sol process of centrifugal dewaxing has several advantages. Any lubricating stock may be successfully dewaxed. The stock may be dewaxed either in its raw residual state or after distillation, hydrogenation, or solvent extraction. It will handle paraffine distillates and not only produce therefrom an oil of satisfactory cold test but a wax which will readily sweat. The pour test of the finished oil closely approaches the temperature at which the oil is centrifuged. The dilute stock may be chilled at a rapid rate with a relatively large temperature differential between the oil and the chilling medium. The temperature rise of the wax-free oil solution through the centrifugals is low, which permits a maximum heat recovery and by which refrigeration requirements are held to a minimum. The operation is carried on at atmospheric pressure. The recovery of oil by rerunning the wax with additional solvent with the return of recovered oil solution to the primary dewaxing operation results in a high yield of oil and a wax of low oil content with a substantially lower installation and operating cost for refrigeration and solvent recovery than is the case in those processes using filters for wax separation, in which the wax washing solvent represents extra refrigeration and the recovered oil solution extra solvent recovery.

The solvent employed is a mixture of ethylene dichloride and benzol, stable and non-corrosive, and there has recently been developed for the process a solvent mixture which is non-inflammable.

The flow diagram on the opposite page shows the diluting, chilling and centrifugal separating steps of the Bari-Sol process.

A description of the manner in which the process operates follows: Stock, solvent and recovered oil dilution (from the rerun centrifugals) are blended in a homogeneous mixture in the heating and blending tank, which is provided with suitable agitator and steam coils for heating, if necessary. The blended stock and solvent dilution, in proportion of approximately three parts of solvent to one of stock, is then charged in series first through the exchanger, chilling machines, countercurrent to the cold dewaxed oil dilution, and then through the direct ammonia expansion chilling machines to the primary centrifugals.

The dilute dewaxed oil discharges from the primary centrifugals to a run tank and is then transferred to the solvent recovery unit at the plant capacity rate through the exchanger chilling machines countercurrent to the processing stock for the recovery of refrigeration.

The waxy stream discharged from the primary centrifugals flows to a run tank from which it is charged at the plant capacity rate to the rerun or secondary centrifugals. At the ends of the rundown header to the run tank cold solvent make-up is added in order to assist the flow of the waxy discharge to the run tank and to increase the solvent to waxy oil ratio. The run tank is provided with a slow-speed wide-sweep agitator to insure a uniform blend of the waxy discharges from the centrifugals and the make-up solvent.

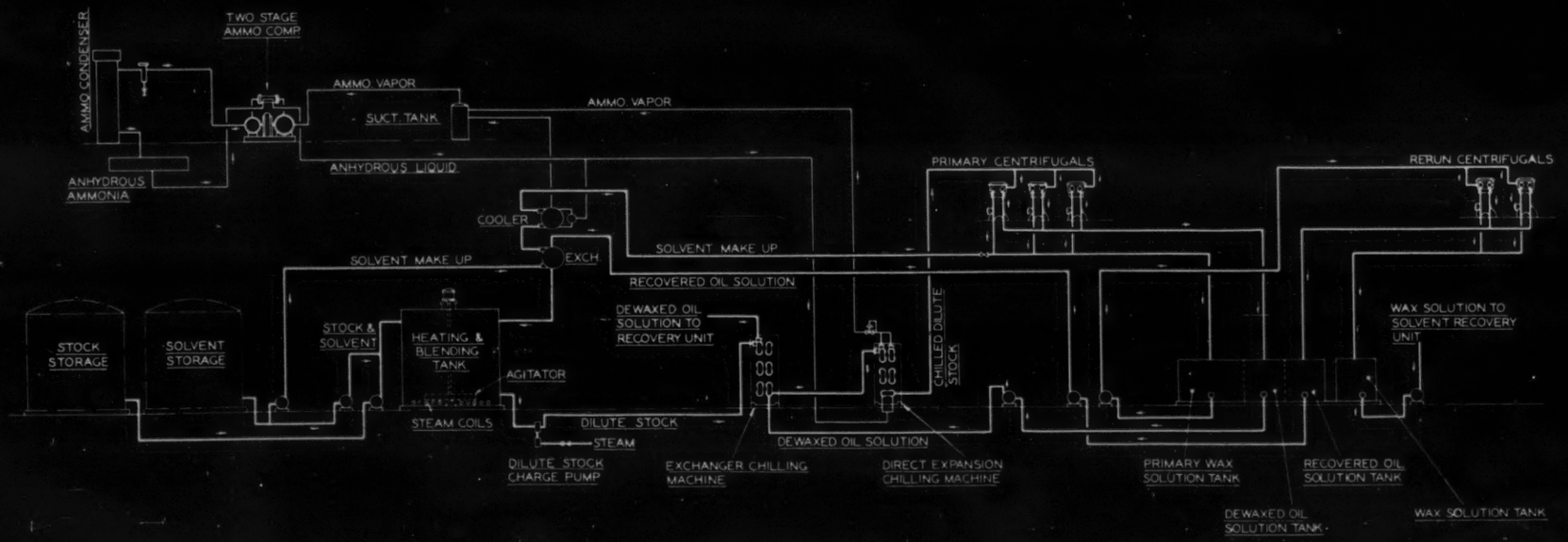
The recovered oil solution discharge from the rerun centrifugals flows to a run tank and from here is discharged to the blending tank. On the way to the blending tank the recovered oil solution is exchanged with the solvent make-up of the rerun centrifugals through a shell and tube type exchanger for recovery of refrigeration.

The wax solution discharged from the rerun centrifugals flows into a run tank and is then transferred to the solvent recovery unit for the continuous recovery of solvent.

Provisions are made so that dewaxed oil is furnished under pressure to the gland seal rings of the chilling machines and of pumps handling solvent or solvent dilution so that there will be no loss of solvent in leakage from this source.

The photograph insert on the opposite page shows a number of the centrifugals in the installation of the Bari-Sol process at the Ponca City Oklahoma refinery of the Continental Oil Company.

THE BARISOL PROCESS



COURTESY, THE SHARPLES CORPORATION

Duo-Sol Solvent Extraction Process

THE Duo-Sol Process developed by the Max B. Miller & Company, Inc., 501 Fifth Avenue, New York, N. Y., and presented here through the courtesy of that company, is a solvent refining process producing from any stock a maximum yield of lubricating oil of any quality desired.

The basic principle of the Duo-Sol Process is the simultaneous use of two practically immiscible solvents in an extractor system having one or more extract stripping stages in addition to the conventional raffinate stripping stages. Propane is employed as a paraffinic solvent and Selecto, a blend of phenol and cresol, is the selective naphthenic solvent. Separation of the two layers in each extraction stage is accomplished by gravity.

The Selecto layer takes into solution the asphaltic unstable and otherwise undesirable fractions of the charge stock. The propane layer carries the stable paraffinic lubricating fractions. The two solvents flow countercurrently through the extractor system, the stock charge being introduced at an intermediate stage. As is shown in the flow sheet, the extract layer is contacted with an increasingly concentrated propane solution in flowing from stage 3 to stage 1, and is thereby stripped of any paraffinic fractions it might contain. In a similar manner, as the propane-raffinate layer flows in the opposite direction from stage 3 to stage 7, it comes into contact with a more and more concentrated solution of Selecto, thus being stripped of its asphaltic oil content.

Advantages of the use of a two-solvent system employing an extractor containing an extract stripping section as well as a raffinate stripping section, are as follows:

(a) Greater Flexibility. The flexibility of the Duo-Sol process permits the treatment of distillates or residuums from any type of crude, producing a paraffinic oil which, when dewaxed to a zero pour, will in most cases have a viscosity index of 100 or higher. On the other hand, the Duo-Sol process permits the production of the maximum yield of lower quality finished stocks if such an operation is desirable.

(b) Low Overall Operating Costs. The overall cost of producing the finished lubricating oil is greatly reduced since acid treatment is entirely eliminated and clay treatment is cut to a minimum. Because of the ability of the process to handle any type of charging stock, the costs of primary distillation and final fractionation into blending stocks for a full line of motor oils are curtailed.

(c) High Quality of Raffinate. The raffinates obtained by this process are not only high in viscosity index but are exceptionally low in carbon residue, resistant to oxidation, stable as to color, and when lightly filtered will meet any emulsification tests.

(d) Maximum Selectivity. The selectivity of this process is excellent as is shown by the specific gravities of the extracts which range from 1.01 for a light distillate to 1.098 or higher for a heavy residual charging stock.

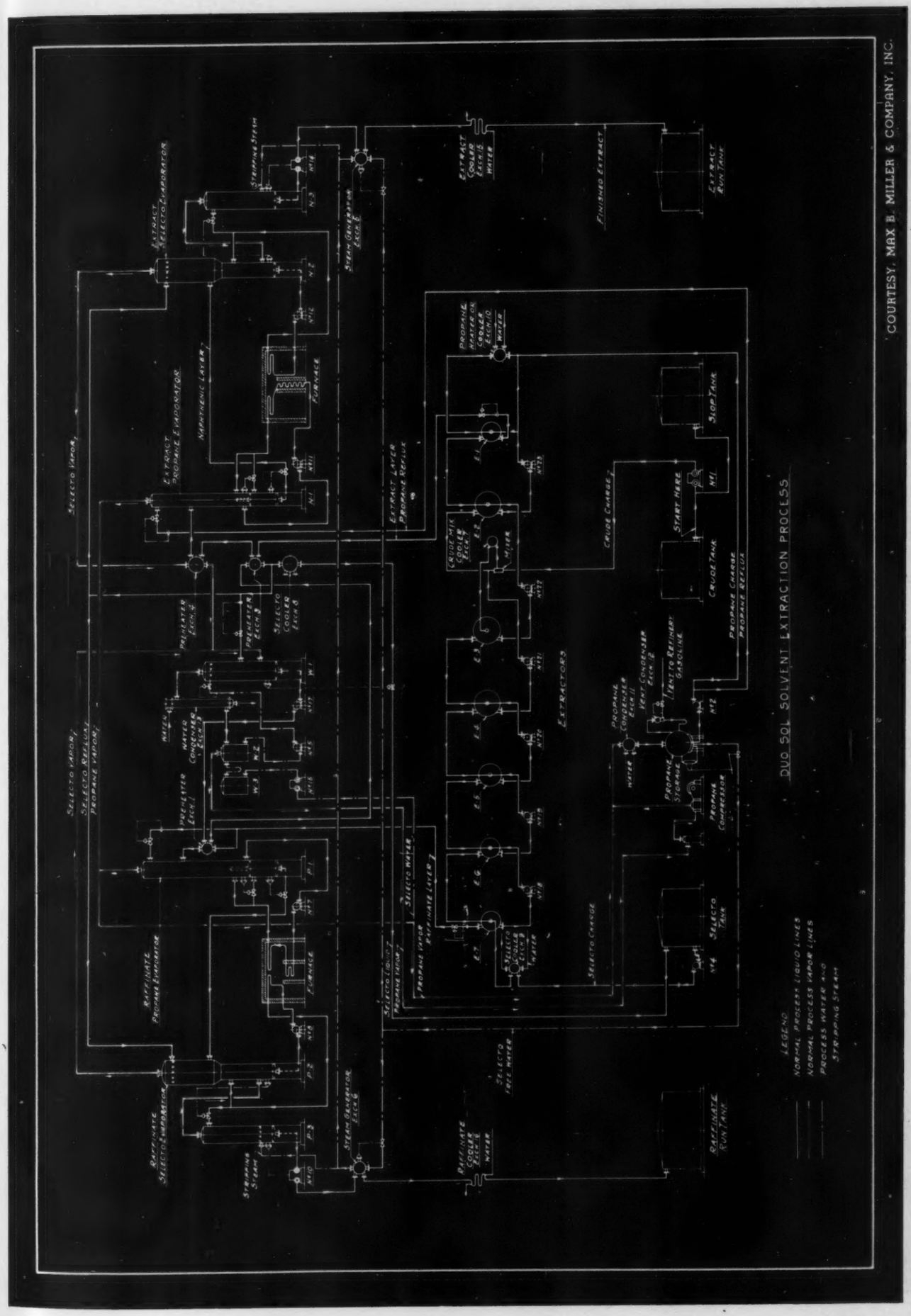
The number and capacity of the existing Duo-Sol installations indicate that the above mentioned advantages are obtainable in actual commercial practice. At present there are in operation in this country five plants having a combined charge capacity of 14,000 barrels per day. There are also five plants abroad having a total capacity of 8,500 barrels per day charge. There are in the process of construction four plants in foreign countries and two plants in the United States having a total capacity of over 11,000 barrels per day.

The flexibility of the process is demonstrated by the fact that in the space of a month and a half one of the commercial plants has treated satisfactorily a light and a heavy Colombian distillate having gravities of 21.2° A.P.I. and 19° A.P.I. respectively, an Oklahoma City distillate having a gravity of 28.8° A.P.I., and an Oklahoma City residuum having an A.P.I. gravity of 21.0°.

Solvent recovery from each layer is accomplished by vaporization of propane in a high pressure tower and the stripping of Selecto from each layer in a low pressure tower. Suitable exchange is provided for the recovery of the maximum amount of heat. Separation of the stripping steam from the Selecto is accomplished by taking a constant boiling mixture overhead from Tower W-1 and decanting in Towers W-2 and W-3.

Some typical results obtained by this process are tabulated below. As can be seen, charging stocks ranging from a light transformer oil to the heaviest crude bottoms can be readily handled in the same plant.

Characteristics of Charging Stock	Transformer Oil	Mid-Continent Distillate	Oklahoma City Residuum	South Texas Tar
Gravity A.P.I.	24.5	25.4	24.2	1.001 Sp. Gr.
Vis. @ 210° F. S.S.U.	64.5 @ 100	48	78	2700
Flash ° F.	300	430	400	.....
Raffinate (Dewaxed):				
Gravity A.P.I.	27.0	31.1	29.2	26.2
Vis. @ 210° F. S.S.U.	63 @ 100	97 @ 130	60	182.0
Pour	0° F.	0° F.	0° F.	0° F.
V. I.	.....	98	100	95.5
Color NPA (before filtering)	1	3	8—	7—
Yield, percent (Duo-Sol)	88.0	78.3	77.8	27.0
Specific Gravity of Extract	1.012	1.015	1.032	1.04


DUO SOL SOLVENT EXTRACTION PROCESS
COURTESY, MAX B. MILLER & COMPANY, INC.
LEGEND
NORMAL PROCESS LIQUID LINES
NORMAL PROCESS VAPOR LINES
PROCESS WATER AND STRIPPING STEAM
EXTRACT SELECTO EVAPORATOR
EXTRACT PROPANE EVAPORATOR
NAPHTHENIC LAYER
FURNACE
SELECTO VAPOR
SELECTO REFLUX PROPANE VAPOR
EXTRACT LAYER PROPANE REFLUX
PREHEATER EXCH. 4
PREHEATER EXCH. 3
SELECTO COOLER EXCH. 8
WATER CONDENSER EXCH. 9
PREHEATER EXCH. 1
RAFFINATE PROPANE EVAPORATOR
RAFFINATE SELECTO EVAPORATOR
STEAM GENERATOR EXCH. 6
STRIPPING STEAM
RAFFINATE COOLER EXCH. 5
WATER
SELECTO FREE WATER
RAFFINATE RUN TANK
SELECTO LIQUID
SELECTO WATER
PROPANE VAPOR
RAFFINATE LAYER
SELECTO COOLER EXCH. 7
SELECTO TANK
SELECTO CHARGE
EXTRACTORS
PROPANE CONDENSER EXCH. 11
VENT CONDENSER EXCH. 12
TO TO REFINERY GASOLINE
PROPANE STORAGE
PROPANE COMPRESSOR
CRUDE MIX COOLER EXCH. 2
MIXER
CRUDE CHARGE
CRUDE TANK
PROPANE CHARGE
PROPANE REFLUX
START HERE
SLOP TANK
PROPANE EXTRACT COOLER EXCH. 10
STEAM GENERATOR EXCH. 13
STRIPPING STEAM
EXTRACT COOLER EXCH. 15
WATER
FINISHED EXTRACT
EXTRACT RUN TANK

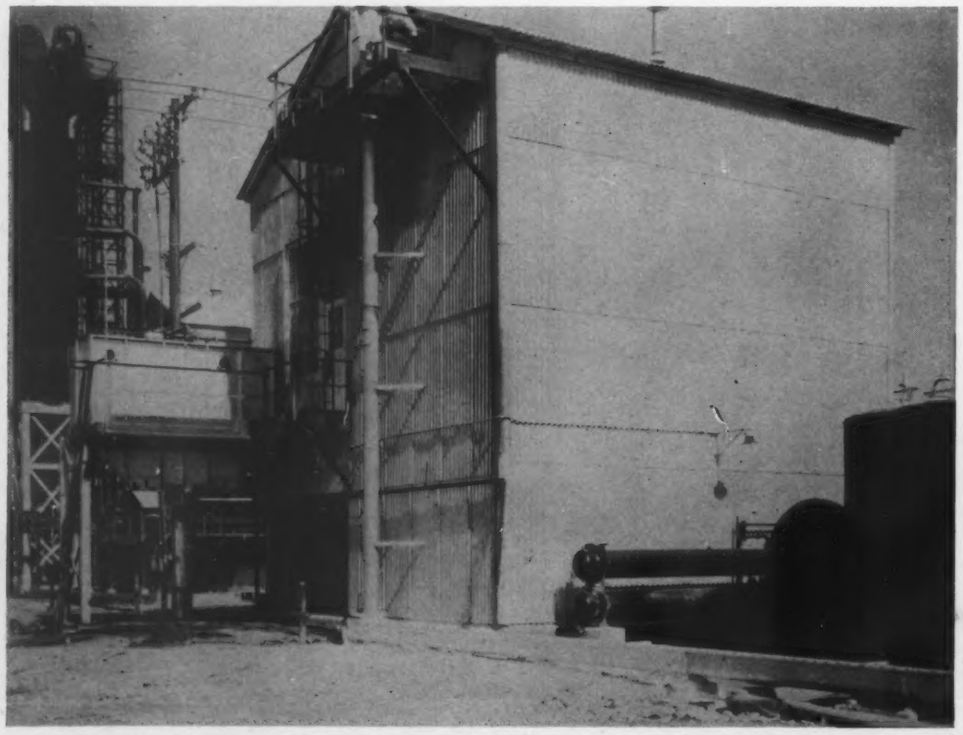
Filtrol Fractionation Process

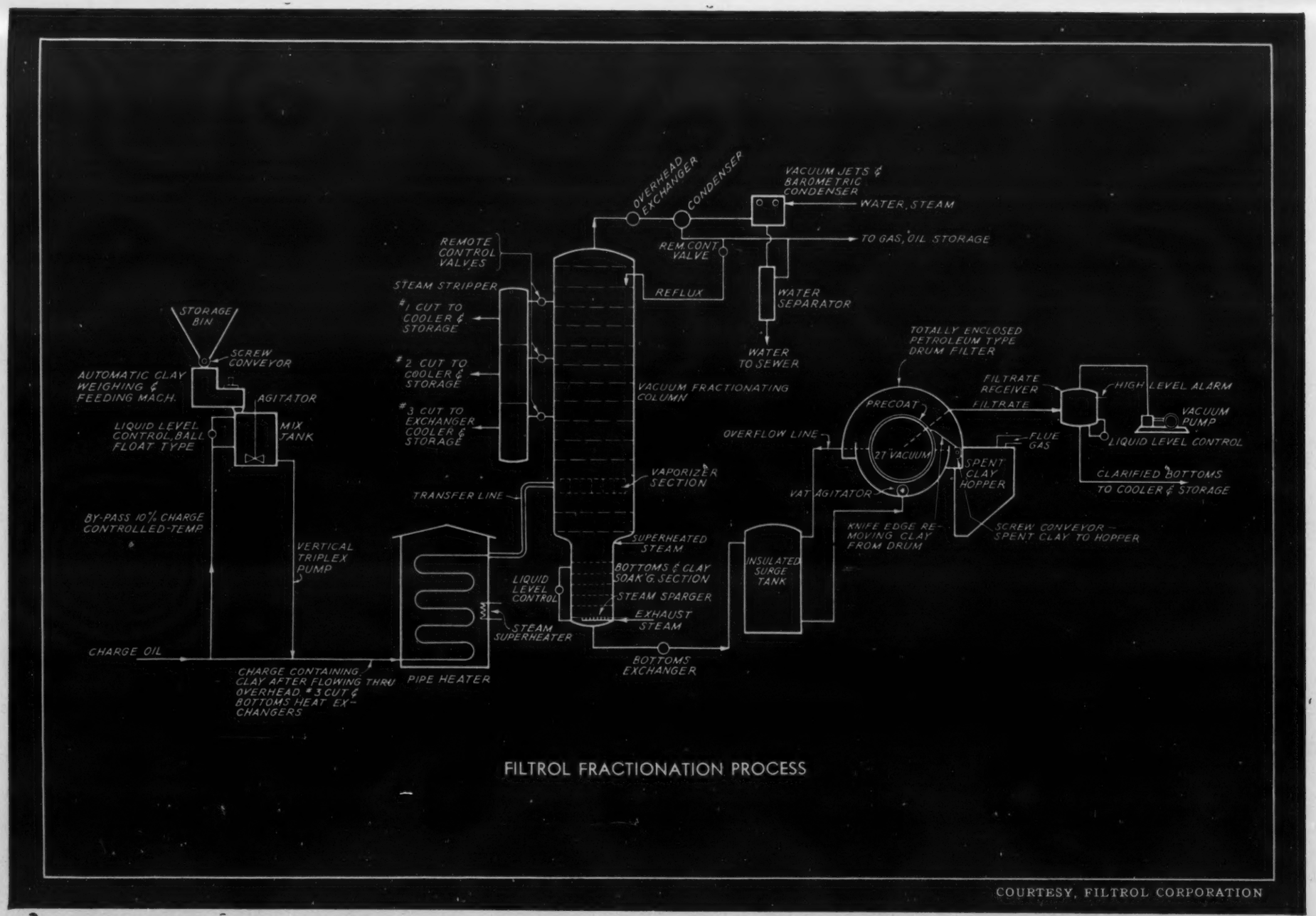
FILTROL Fractionation is the name of the process in which Super Filtrol, a highly activated bleaching clay, is injected into a hydrocarbon oil stream as it flows to fractional distillation equipment. The purpose of this relatively new technique is to combine fractional distillation and contact clay decolorization into a single and more economical continuous process. The process is applicable to the refining of solvent treated stocks, long residuals, low asphaltic or treated lube crudes, and dewaxed cylinder bright stock solutions. By combining distillation and decolorization, substantial savings in equipment, upkeep, maintenance and operating costs are affected.

On the opposite page is a flow diagram of a Filtrol Fractionation plant presented through the courtesy of Filtrol Corporation, 315 West Fifth Street, Los Angeles, California. As indicated in the flow sheet a portion of the charge to the pipe heater is continuously by-passed through a small clay mix tank. This tank is equipped with a mechanical agitator which mixes the clay with the oil, thus forming a readily pumped oil clay slurry. The clay is automatically fed to this tank by a gravimetric feeder insuring accurate control of the clay feed at all times. The feeder is kept automatically supplied with clay by a scroll-type conveyor which takes clay from the overhead storage bin. The by-passed oil containing clay rejoins the main flow of the charge and continues through the heat exchangers before entering the pipe heater. The temperature of the heater outlet is automatically controlled. The hot oil clay slurry then enters the vaporizer section of the vacuum fractionating column where the unvaporized portion which contains all the clay passes over a number of stripping trays before falling into the soaking section. The lighter cuts thus receive a clay treatment in passing through the exchangers and furnace, after which the clay charge is concentrated in the bottoms which require heavier clay treatment. The vaporized material is fractionated into the desired cuts, each of which passes through a steam stripper which eliminates all undesirable odor and insures color stable products

The bottoms and clay in the soaking section of the tower are agitated and stripped by the injection of steam into the bottom of the vessel. The soaking time or contact time is regulated by automatically controlling the liquid level in this section. The slurry then passes through the bottoms exchangers and into an insulated surge tank from which a continuous vacuum rotary filter is fed. The clay is continuously filtered from the oil which passes through a cooler to finished oil storage. The spent clay is continuously removed by a screw conveyor.

Features which make recent installations an advance in the art of finishing lubricating oils are careful control of contact time and temperature, steam stripping and continuous filtering of the products, and completely automatic clay handling.





FILTROL FRACTIONATION PROCESS

COURTESY, FILTROL CORPORATION

Specialty Absorption Process

90% PROPANE SEGREGATION FROM GASES

FOSTER WHEELER

THE last few years have indicated a greatly increased demand for products of the petroleum industry in fields of general chemistry and involving the segregation of a greater percentage of certain compounds with a high degree of purity. This trend has brought about the development of special absorption and fractionation equipment.

A representative absorption unit for the production of liquid propane and liquid butane in a commercially pure state is illustrated in the accompanying arrangement drawing, presented through cooperation of Foster Wheeler Corporation, 165 Broadway, New York, N. Y. It is recognized that an absorption plant may easily be designed to absorb propane and butane from a given gas charge and to deliver a relatively pure product but it is not simple to absorb 90 percent of the total propane in the gas economically and to deliver it as a liquid with the same high degree of purity.

One of the chief difficulties to be overcome lies in the fact that the degree of selectivity decreases as the percentage of absorption increases. In order to maintain sufficient selectivity in the absorption process it is necessary to eliminate a substantial part of the methane and ethane from the enriched oil at an early stage in the process. Due to this phenomenon of progressively decreasing selectivity, it has only recently been found commercially practicable to obtain 90 percent propane segregation without resort to subatmospheric temperatures. However, the unit described herewith delivers this proportion of the propane as well as 100 percent of the heavier constituents.

The charge consists of gases from cracking units which enter the absorber below the bottom tray and pass up through a series of bubble trays. Ninety percent of the propane and 100 percent of the heavier constituents are removed from the incoming gases and absorbed in the lean oil that flows downward over the trays. The gases that are not absorbed, including a small quantity of propane together with methane and ethane, are taken overhead from the top of the absorber for fuel gas in the refinery system. Loss of this propane from the process is unavoidable in practice because of the necessity of maintaining selectivity and restricting the degree of absorption. The process of absorption is accompanied by the generation of considerable heat, which must be extracted in order to keep the temperature of absorption within the desired range and to minimize the lean oil requirements. This is accomplished by an inter-cooler.

After being enriched by the addition of over 90 percent of the propane and all of the heavier constituents, the absorption oil is passed from the bottom of the absorber into a demethanizer tower. Here, most of the remaining methane and a considerable amount of the ethane are stripped out and recycled to the absorber. A reboiler at the bottom of the demethanizer furnishes the stripping vapors for this tower.

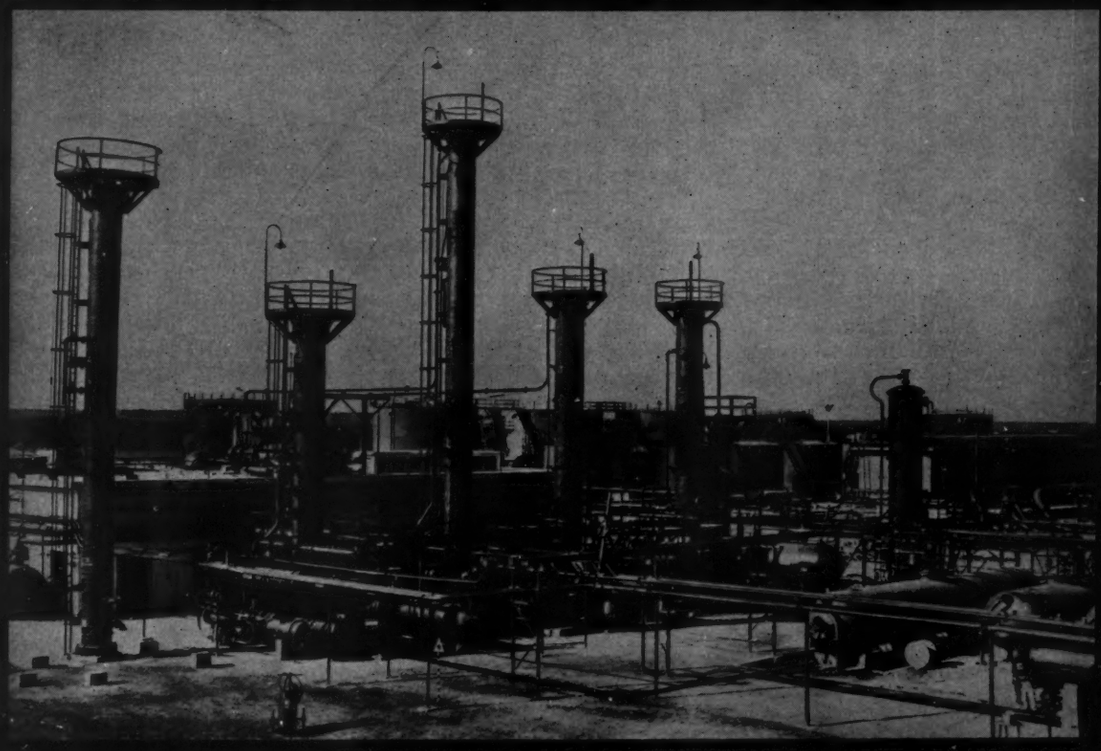
From the bottom of the demethanizer tower, the demethanized rich absorption oil is conducted into the center section of a stripping still. A reboiler at the bottom of the still furnishes stripping vapors for denuding the rich absorption oil of the absorbed fractions. The denuded oil from the bottom of the still is recycled to the top of the absorber and used over again as an absorption medium. Gasoline is distilled overhead, condensed, and recovered in a gasoline receiver. Part of the gasoline is sent to the top of the still for refluxing purposes. Non-condensable gases which are relatively small in quantity are recycled from the gasoline receiver back to the absorber.

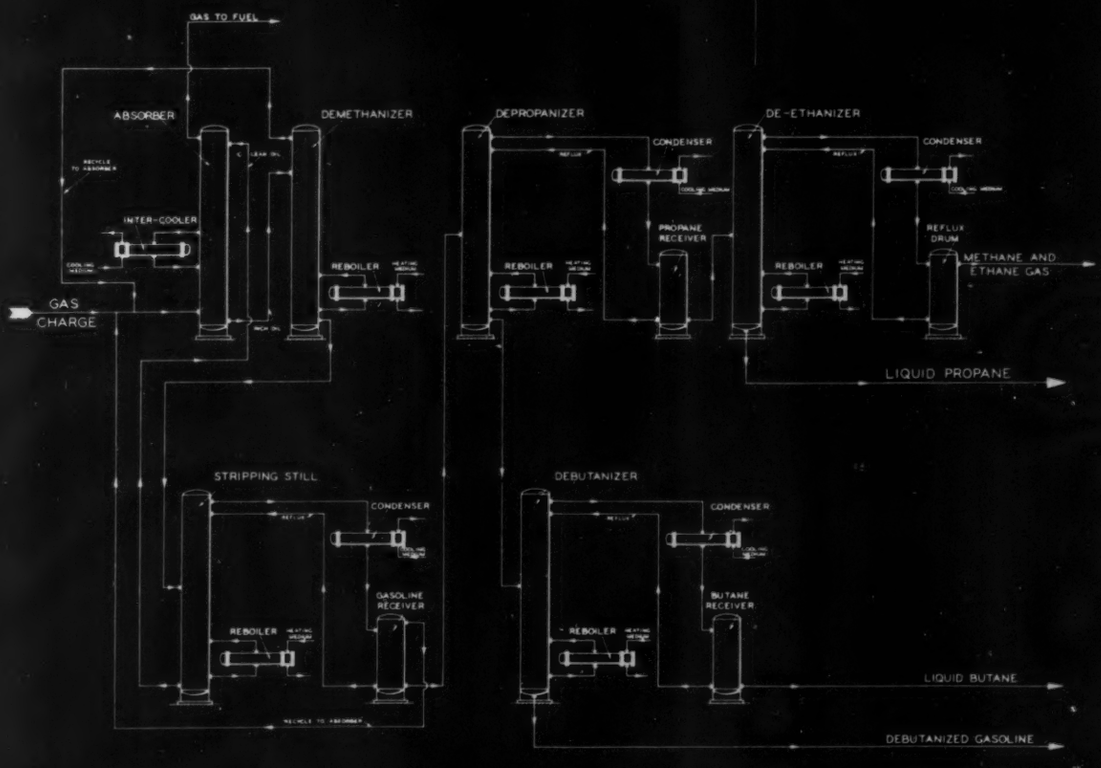
The net gasoline yield is charged from the gasoline receiver directly into a depropanizer. A reboiler furnishes stripping vapors for removing all of the propane and lighter constituents. These vapors are passed overhead, condensed and collected in a propane receiver. Part of the propane distillate is returned to the top of the depropanizer as reflux.

The net overhead product of propane and lighter fractions is pumped from the propane receiver into a de-ethanizer tower. Stripping vapors for eliminating the ethane from the propane are obtained from a reboiler at the bottom of the de-ethanizer. The ethane in the charge and a very small amount of propane is distilled overhead and enough is condensed and collected in a drum to furnish adequate reflux in the tower. Non-condensable gases including all of the methane and ethane remaining up to this point, as well as a slight amount of propane, are discharged from the reflux drum into the refinery fuel gas system. The bottoms product from the de-ethanizer tower consists of commercially pure liquid propane and is conducted to storage.

The butanes and heavier components that are contained in the original charge are carried through the system with the lighter fractions as far as the depropanizer. They remain in the depropanizer bottoms after the propane and lighter constituents have been carried off overhead and are fed into the middle of a debutanizer tower. A reboiler in the bottom of this column furnishes stripping vapors for distilling off the butane. The bottoms from the debutanizer tower consist of debutanized gasoline that may be blended into the general refinery production. The overhead, consisting of butane, is condensed and collected in a butane receiver. Part of this product is returned to the top of the tower as reflux. The remaining net overhead yield, consisting of all of the butane contained in the original charge, is then sent to storage as commercially pure liquid butane.

In this manner complete segregation of commercially pure propane and butane is accomplished with a yield of 90 percent of the propane, as well as 100 percent of the butane, contained in the charge to the absorption process.





SPECIALTY ABSORPTION PROCESS

The Furfural Refining Process

FURFURAL is widely used as a selective solvent in refining of lubricating oil. The solvent selectivity ranks high among the commercially-available solvents; the cost of furfural is relatively low and, being manufactured from agricultural wastes, the supply is adequate. Furfural is relatively non-poisonous and no special precautions are taken in commercial handling of the solvent. The successful application of furfural to a wide range of lubricating oils has been demonstrated in a large number of commercial operating installations, and additional plants are being installed at present. This discussion is presented through the cooperation of the Texaco Development Corporation, 135 East 42nd Street, New York, New York, licensors of the process.

The first furfural refining unit was installed at the Indian Refining Company at Lawrenceville, Illinois, and has been in constant operation since November, 1933. Waxy distillate oils from Mid-Continent and Illinois crudes, the distillates ranging in viscosity of from 40 seconds to 170 seconds Saybolt at 210° F., have been successfully treated. The stocks processed in other plants, with a charging capacity of over 30,000 barrels per day of lubricating oil, including a wide range of naphthenic and paraffinic distillates and residues from a wide variety of American and foreign crude oils.

Furfural is very stable. This is illustrated by the fact that plant inventories over long periods of operation show a solvent loss of only .03 percent of the total solvent used, even though operating in some instances at temperatures as high as 550° F. A maximum temperature of 450° F. is now normally maintained in plants, and at this temperature furfural is easily recovered from the oil products. A closed system is used in plant operations, but no inert gas protection is required to preserve the solvent. The original solvent charged to the unit is maintained at a light straw color and shows no changes in physical properties.

The flow sheet on the opposite page reflects a typical layout of equipment employed in the process. Furfural, however, because of its stability over a wide range of operating conditions lends itself to a variety of methods of recovery from raffinate and extract solutions. Different types of the solvent recovery systems have been developed, in order to provide for maximum operating economy of each particular installation.

Furfural is introduced into the extraction system at temperatures normally ranging from 150° F. to 250° F., at which temperatures practically any viscous or waxy oil can be readily handled. The oil viscosities at temperatures of application and a large difference in specific gravity between extract and raffinate solutions permit counterflow operation at high charge and settling rates in a single, packed tower.

The advantages of a packed counterflow tower are: Lower solvent and oil quantities in the system; lower initial investment; lower operating and maintenance costs and greater simplicity of operation and control.

Untreated oil is charged to the extraction tower at a predetermined temperature while furfural is charged to the top of the tower, just below the surge space provided for accumulation of raffinate mix. Normal operation calls for a substantial temperature gradient between the top and bottom temperature of the tower. The tower is maintained full of oil with the furfural flowing downward through the oil. Refined oil solution containing only a small percentage of furfural flows from the top of the treating tower by gravity through heat exchangers and fired heater to a combination flash tower and steam stripper in which the final traces of furfural are removed.

The extract solution, containing the major portion of furfural, is pumped through heat exchangers and a fired heater to a pressure flash tower, where over 50 percent of the furfural contained in the extract mix is vaporized. The flashed solution then flows under pressure through pressure reducing valve to a vapor heat exchanger in which substantially all of the remaining furfural is vaporized by heat recovered condensing a large percentage of the pressure vapors from the primary flash tower. The extract, plus a small percentage of furfural in equilibrium with it, then flows by gravity to a steam stripper in which the furfural is removed.

Heat is recovered from the furfural vapors from both atmospheric and pressure flash towers by exchange with extract solution. Additional heat is recovered from the pressure condensate by exchange with the extract mix, after which pressure is released, and the furfural admitted to the main furfural charge accumulator, whence it is again charged to Treating Tower.

Vapor from the two steam strippers, together with vapors from the two fractionating columns, is condensed in a common condenser, and the condensate allowed to separate into two layers in the separating drum.

The recovery of furfural from water is a very simple process, due to the fact that a mixture of furfural and water boils at a lower temperature than either pure water or furfural. Furfural can, accordingly, be easily stripped from any mixture of the two components.

The plant represented herewith comprises the following:

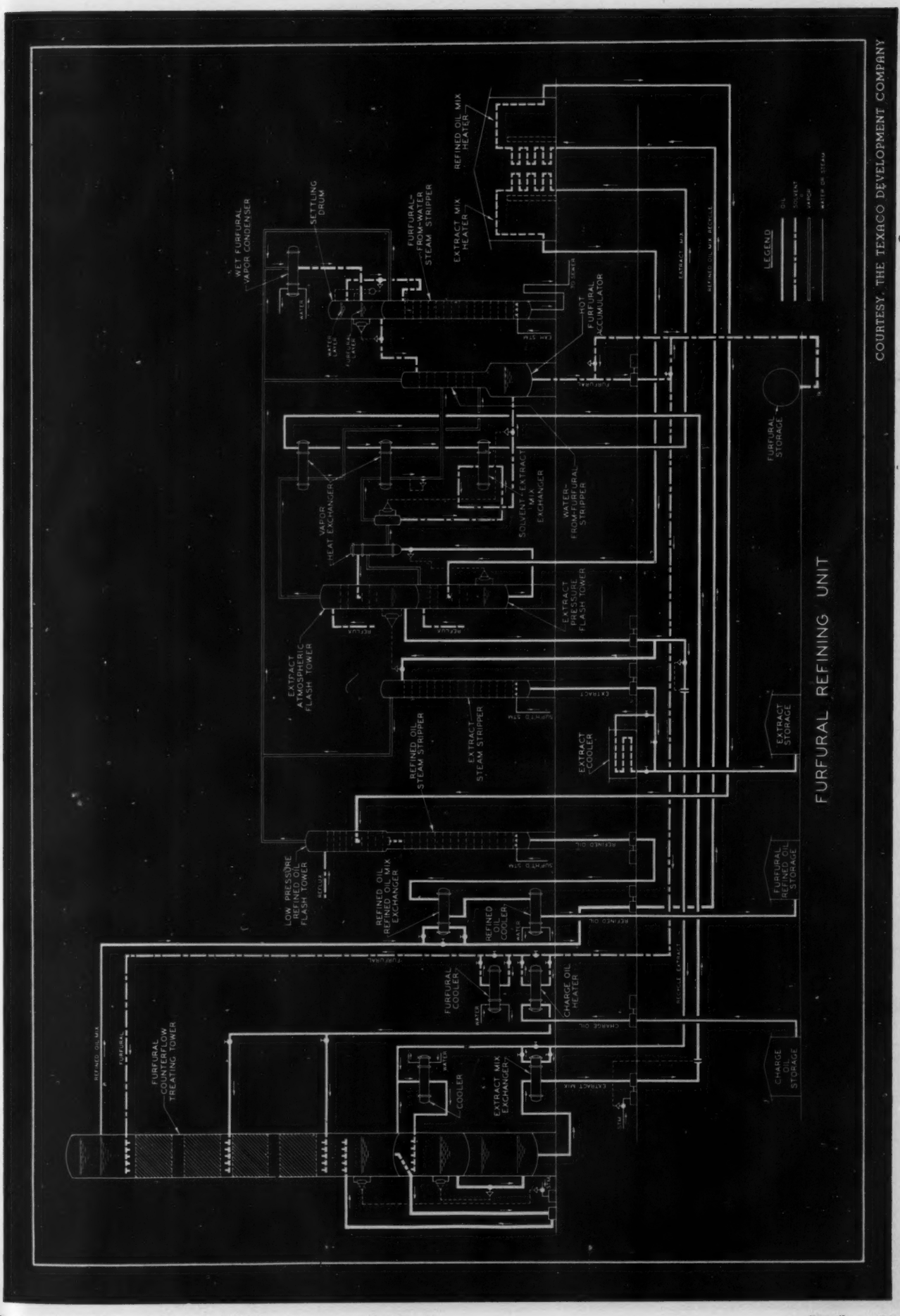
1. Vertical counterflow extraction tower with suitable exchange, cooling and extract recycle equipment to provide means for continuously treating the charge oil with furfural at controlled, pre-determined temperatures and rates of flow.

2. Surge capacity in the treating tower itself for storage of raffinate and extract solutions, prior to charging these solutions to respective solvent recovery equipment.

3. Solvent-from-extract recovery unit, including open steam stripper for removal of final traces of furfural from extract.

4. Solvent-from-raffinate recovery unit, including steam stripper.

5. Solvent-from-water recovery system, including settler and two fractionating columns. The settler is required to permit the mixture of water and furfural condensate to separate into two layers; the lower layer being rich in furfural and the upper layer rich in water. One of the fractionating columns is employed in stripping water from the furfural layer, using furfural vapors as a stripping medium, and the second column is employed in stripping furfural from the water layer, using exhaust steam in the base of the column to furnish the necessary heat.


FURFURAL REFINING UNIT
COURTESY, THE TEXACO DEVELOPMENT COMPANY
LEGEND
OIL
SOLVENT
VAPOR
WATER OR STEAM
WET FURFURAL VAPOR CONDENSER
SETTLING DRUM
FURFURAL-FROM-WATER STEAM STRIPPER
EXTRACT MIX HEATER
REFINED OIL MIX HEATER
HOT FURFURAL ACCUMULATOR
VAPOR HEAT EXCHANGER
SOLVENT-EXTRACT MIX EXCHANGER
WATER-FROM-FURFURAL STRIPPER
EXTRACT ATMOSPHERIC FLASH TOWER
EXTRACT PRESSURE FLASH TOWER
REFINED OIL STEAM STRIPPER
EXTRACT STEAM STRIPPER
EXTRACT COOLER
FURFURAL STORAGE
EXTRACT STORAGE
LOW PRESSURE REFINED OIL FLASH TOWER
REFINED OIL MIX EXCHANGER
REFINED OIL COOLER
FURFURAL REFINED OIL STORAGE
FURFURAL COUNTERFLOW TREATING TOWER
FURFURAL COOLER
CHARGE OIL HEATER
COOLER
EXTRACT MIX EXCHANGER
CHARGE OIL STORAGE

High Pressure Gas Recycling Process

THE flow sheet on the opposite page diagrammatically illustrates the principal flow through a typical high pressure absorption type pressure maintenance process, designed by the Mid-Continent Engineering Company, 112 Guardian Life Building, Dallas, Texas.

The term recycling plant is commonly used when referring to the production of distillates from true gas-phase structures by extraction and pressure maintenance systems. The following process is designed to extract finished motor gasoline, as well as heavier end point distillates, and at the same time accomplish gas recycling and repressuring.

Careful consideration is given to the high pressure gas piping to and from producing and input wells. The gas from the producing wells is cooled to a desirable absorbing temperature by water cooler H-1 and passed through a separator, or direct to one or more high pressure absorbers indicated as V-1, depending on the capacity of the plant. The absorption towers are equipped with bubble trays and with double mist extractors to prevent carryover of oil. The absorbers are operated at pressures from 1200 to 1600 pounds gauge pressure, which materially reduces the horsepower required to return the stripped gas to the input wells, the return pressures varying from 2500 to 3000 pounds gauge pressure. The high pressure absorption system realizes from 95 to 98 percent Iso Pentane and from 60 to 70 percent of Butane extraction efficiency. The absorption oil ratio varies from two to five gallons of oil per 1000 cubic feet of gas. The absorbers have little or no carryover. However, vent tank V-2 is provided to insure against condensates entering the suction line to compressors.

The gas leaving the high pressure vent tanks is returned to the input wells by single stage gas engine driven compressors.

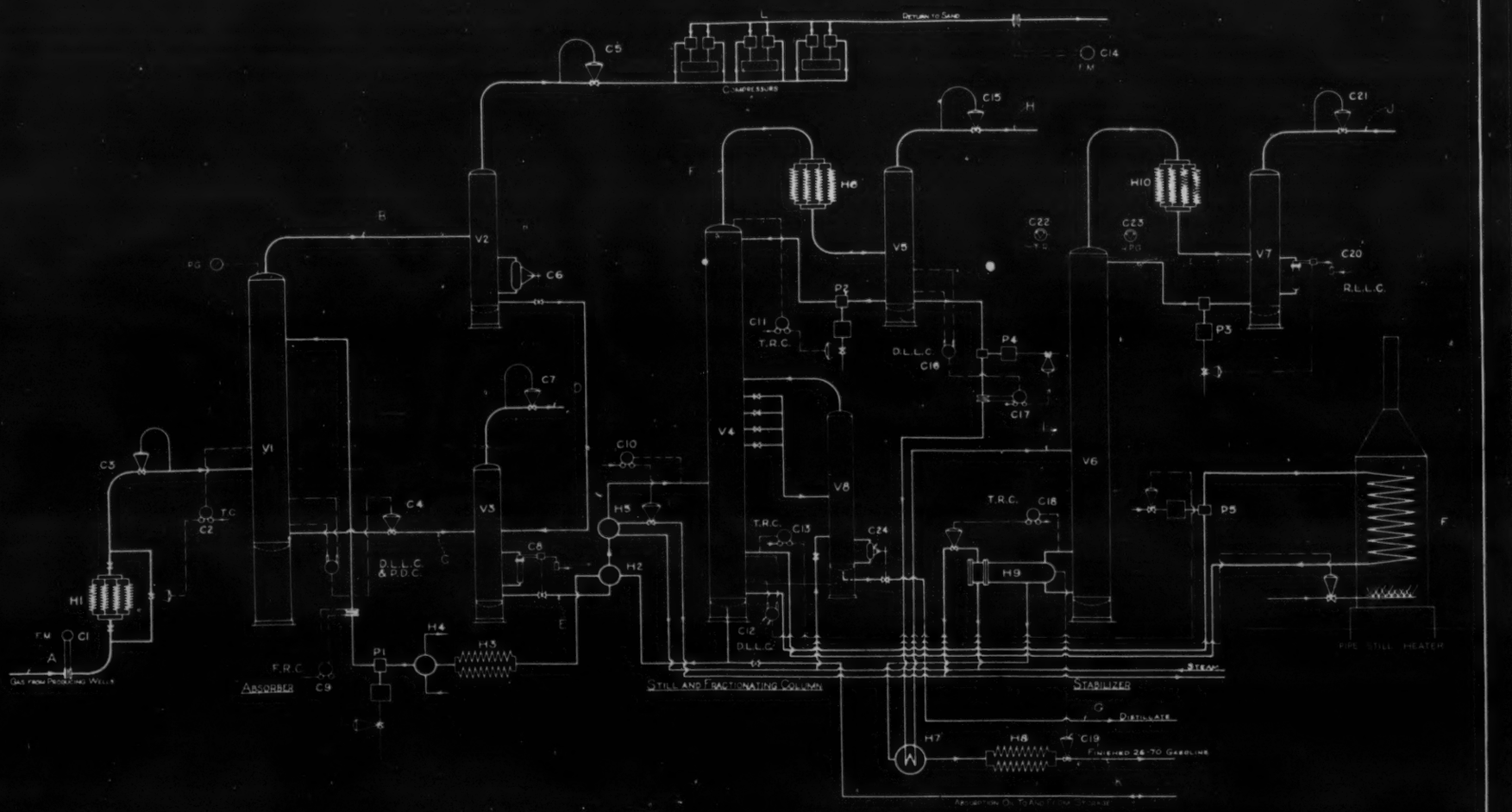
The process provides stage weathering of the rich oil from absorption pressure down to distillation pressure, in vent tanks V-3. The lean oil from the base of the fractionator is cooled in conventional water cooler H-3 and after cooled to a temperature of 70° F. by cooler H-4, using 60° water. The cooling water for the after cooler is cooled to the desired temperature by the use of vacuum steam condensers.

The separation of gasoline, distillate and lean oil is accomplished in a combined still and fractionating column, from which fractionated end point gasoline is removed as an overhead product, condensed in condenser H-6 and accumulated in accumulator V-5. The heavy distillate is removed as a side stream product through stripper column V-8 to desired initial and end point. The heat required for distillation is maintained by circulating the lean oil from the base of tower V-4 through an outside gas-fired pipe still heater, which greatly reduces the steam required for reboiling and stripping in conventional systems.

The fractionated gasoline accumulated in V-5 is continuously discharged to a conventional stabilizing unit where the finished gasoline is stabilized to desired vapor pressure.

The vent gases from the high pressure vent tanks and low pressure accumulators D, H and J may be further passed through a re-absorber for further extraction.

The constantly increasing demand for higher octane gasoline may make advisable the thermal cracking, or reforming of the gasoline and distillates recovered by this process, and consideration of the advisability of treating by pyrolysis and alkylation of the available Butanes and Iso-butanes with the view of producing high octane aviation gasoline.



HIGH PRESSURE GAS RECYCLING SYSTEM

COURTESY, MID-CONTINENT ENGINEERING COMPANY, INC.

Houdry Catalytic Cracking Process

HOUDRY Catalytic Cracking units are a proven source for high octane motor gasoline and aviation fuel. Commercial units are now in operation and operating upon a wide variety of cracking stocks such as topped and reduced crudes and gas oils while the yields obtained have been always equal and usually greater than the predicted results. The Units in operation have been individually designed to fit each refiner's requirements and the commercial results range from the production of a maximum of No. 2 fuel oil and a 78-80 octane motor gasoline of the order of 38 percent to a minimum of No. 2 fuel oil and a maximum once through motor gasoline yield from reduced crude which is above 50 percent. In actual operation the process is flexible and adaptable to the varying refinery demands for gasoline, furnace and gas oils and heavy fuels.

The Houdry Process is simple to operate and the main components of the system are shown on the flow sheet on the opposite page. For a reduced crude charging stock the raw feed is pumped through a vapor heat exchanger and thence to a pipe heater where the temperature is raised to 850° F. and released to the tar separator. The heavy unvaporized portion or pitch is removed from the bottom of the tar separator, passed through a cooler and thence sent to storage for blending off with cracked products for heavy fuel. The vaporized portion passes from the tar separator to one of the catalytic converters, the vapor stream being automatically diverted from converter to converter as required for the regeneration cycle. The catalytically cracked vapors pass through vapor heat exchange to the synthetic crude tower where the gasoline, No. 2 fuel oil and gas oil are fractionated out and passed to storage.

During the regenerating cycle the oil vapor inlets and outlets are automatically closed, a vacuum is pulled upon the converter for removal of oil vapor and then preheated air is admitted from a turbo compressor. The carbon deposit is burned from the catalyst and the excess heat so generated is removed by means of a molten mixture of nitrates and nitrites of sodium and potassium. This excess heat so removed is used for steam generation or preheat of the charge. The gases of combustion from the converter pass to the turbine side of the turbo compressor and have sufficient energy to provide all the power required for air compression and some excess which is used for the generation of electrical power. At the end of the regeneration period a steam jet removes the products of combustion that remain in the converter and after repressuring the catalyst is again ready to receive oil vapor conversion.

Houdry units operate at low pressure and temperature, the latter reducing the corrosion rate and the necessity for extremely expensive alloys for the usual charging stocks. The oil equipment, pumps, pipe still and fractionator are no different than the usual refinery crude unit, the only special equipment being the catalytic equipment and regenerating system. The fuel requirements are low as high yields are obtained on a once through operation and the steam and electrical requirements are generally balanced by the production of those utilities.

The octane number of the gasoline produced by this process is 78-80 CFR-MM and the 39 Research octane is from 7 to 12 points higher. The octane characteristic is approximately the same throughout the boiling range of the gasoline and one fraction is very little different in this respect from any other. This characteristic extends beyond the usual gasoline boiling range and a 440 E.P. product will have the same octane number as a 400 E.P. cut. The raw gasoline is also characterized by low gum and outstanding oxygen bomb stability. In the production of base stock for aviation fuel the stability of the raw gasoline has been tested by storage in steel drums on outdoor storage racks. Such tests have been made in various climates and the results have shown, even for periods as high as 14 months, that there has been little increase in gum or decrease in octane number, the chief change being in Reid vapor pressure. Houdry aviation gasoline shows good blending characteristics with alkylates and polymerized and hydrogenated products. The lead susceptibility is high for this type of material and 88 to 94 octane CFR-MM is attained with 3 cc. of TEL per gallon. Aviation fuel has been commercially produced by the Houdry Process for over two years and the motor gasoline now forms a part of the regular production of two well-known companies.

One of the Houdry Units now under construction will reform naphtha to produce high octane motor fuel or alternately aviation fuel. The reforming process operates in a manner similar to the catalytic cracking process except that a special catalyst is used and the space rates are higher than for heavy oil cracking. Aside from the octane improvement obtained the reformed product has excellent volatility. The yield of aviation fuel obtained from naphtha reforming is somewhat dependent upon the charge stock and varies from 35 to 55 percent. In all cases, with naphtha charge stock, the gum content of the raw reformed aviation fuel is low and the acid heat usually below twenty.

In the previous issue of the "The Refinery Catalog" the description of the Houdry Process reported only four commercial units in operation. As of May, 1940, there are thirteen units operating with a catalytic cracking capacity of approximately 150,000 barrels per day and four plants building which will raise the total capacity to approximately 200,000 barrels per day.

HOUDRY CATALYTIC CRACKING PROCESS
COURTESY, E. B. BADGER & SONS COMPANY
GAS
GAS SEP.
GASOLINE
#2 FUEL OIL
GAS OIL
RED. CRUDE CHARGE
TAR
SYNTHETIC CRUDE TOWER
VAPOR HEAT EXCHG.
COOLING MEDIUM
AIR HEATER
AIR INLET
TURBO-COMPRESSOR
VENT STACK
CONVERTERS
CATALYTIC
TAR SEPARATOR
HEATER
STEAM
STEAM
CASE PURGING SYSTEM
WATER
STEAM
OIL SEPARATOR

Houdry Catalytic Treating Process

THE Houdry Catalytic Treating Process is a vapor phase operation involving the passing of the vapors through a catalyst at a temperature range of 600 to 700° F. and a pressure of 50 pounds gauge. It will be seen from the flow sheet that the gasoline charge is pumped through heat exchange, against the treated vapors, and thence to a pipe heater for final heating and vaporization. From the pipe heater the gasoline is conducted to one of two alternate cases. The treated vapor passes from the treater case to the vapor heat exchangers and thence to a fractionating tower, the gasoline product passing overhead and the polymers from the bottom of the column.

One case is "on stream" for a period of about three hours while the other is being regenerated. The regeneration is accomplished with low pressure air, a motor driven blower passing the air through an air heater and thence to the case, the products of combustion passing to the atmosphere through a stack. The air oxidizes the mercaptan sulfur and any carbon on the catalyst and the heat thus generated is removed by a circulated cooling medium which is made up of a mixture of nitrates and nitrites of sodium and potassium. The heat removed by the cooling medium is used for the generation of steam.

The change over from the treating to the regeneration cycle and vice versa is accomplished by means of motor operated valves. The cycle is not automatically controlled and the valve change is push button operated, with control lights on the instrument board to indicate the existing phase of the cycle.

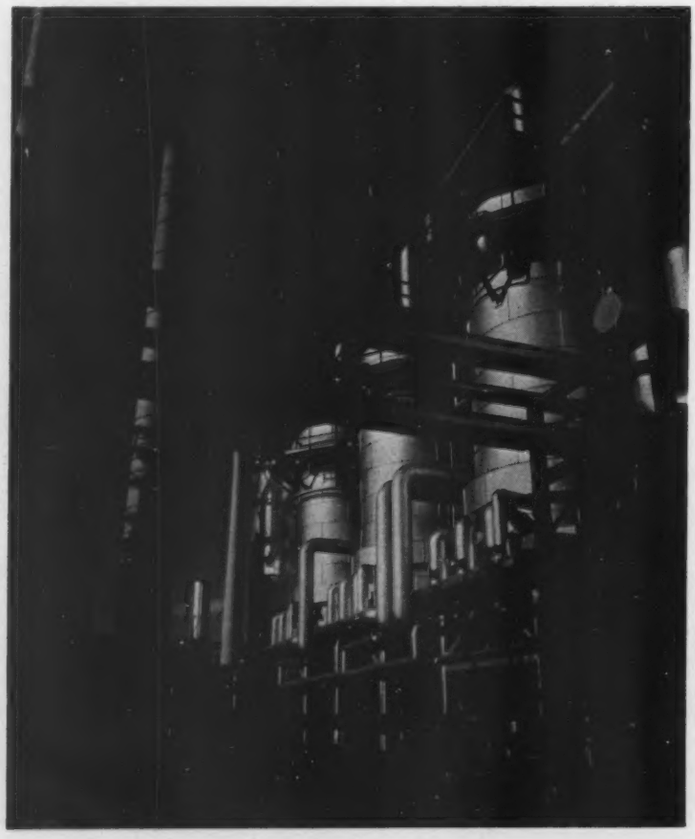
Typical of the results obtained from a commercial unit is the following data:

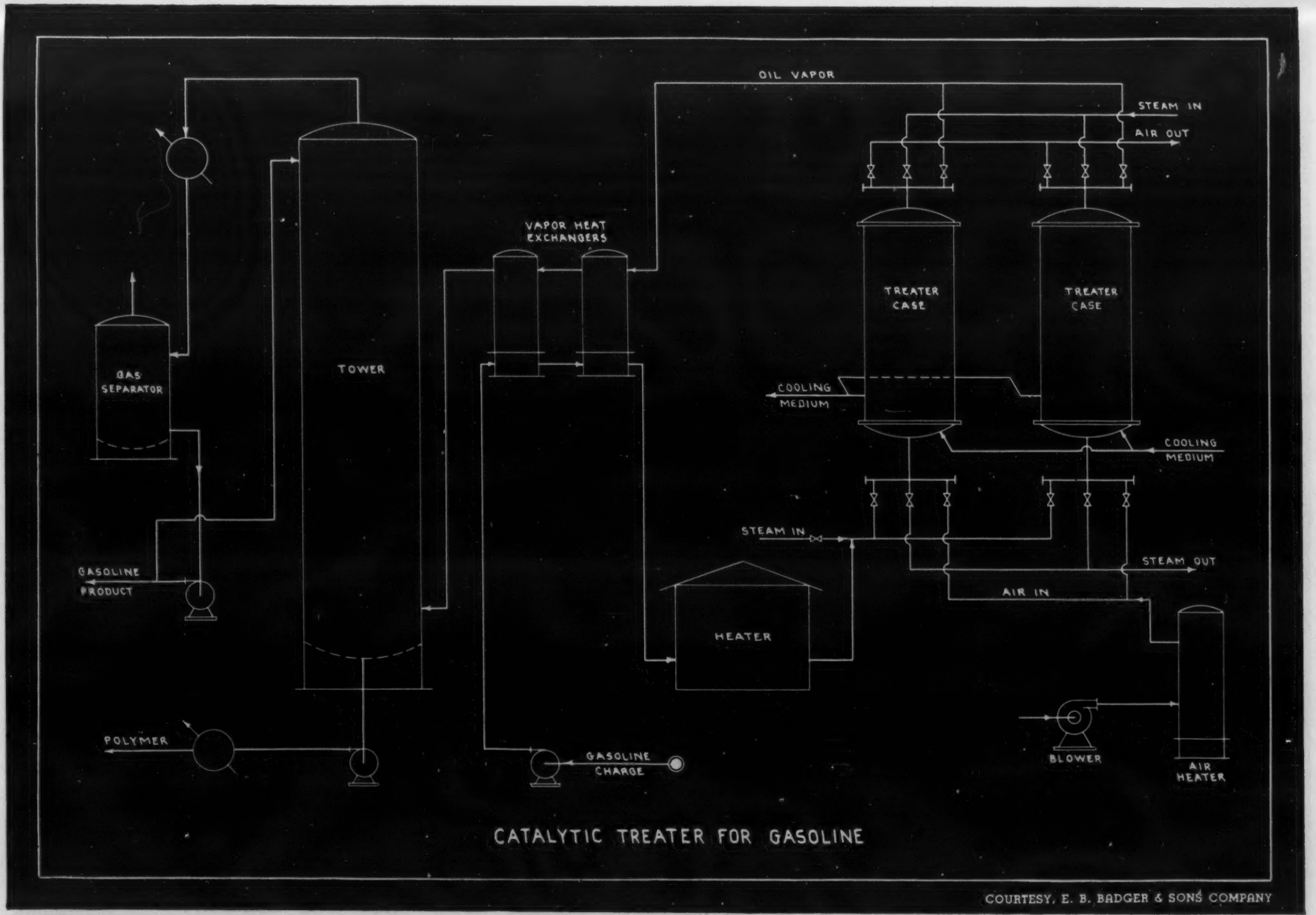
Treater Charge	100 percent
Treated Gasoline	97.7 percent
Polymers	1.5 percent
Loss, Gas, etc.	.8 percent

Tests on Charge and Products:

	Gasoline Charge	Tower Bottoms	Gasoline Product
A. P. I. Gravity	52.6	28.1	53.2
Initial B. P.	94	307	91
5 percent	130	350	134
10 percent	159	364	158
50 percent	298	467	294
90 percent	390	630	381
End Point	423	726	403
Recovery	95	98	95
Color	Too Dark	3¼	28
Cu. dish gum	35	.....	6
A. S. T. M. gum	2	.....	1
Octane C. F. R. M. M.	77.1	.....	77.2
Oxygen bomb	.....	.....	10 Hrs. +
Doctor	Sour	.....	Sweet
Copper strip	Tarnish	.....	Okay

Two large commercial units and one small converted unit are practising this treating method, the combined capacity being approximately 35,000 barrels per day. The larger units are operating upon a mixture of cracked and straight run products while the smaller is used on aviation fuel. The chief advantages which these commercial operations have shown are low treating cost, with a large reduction in gum, a great color improvement and no loss in octane while with aviation fuel the acid heat is reduced to below 20.





CATALYTIC TREATER FOR GASOLINE

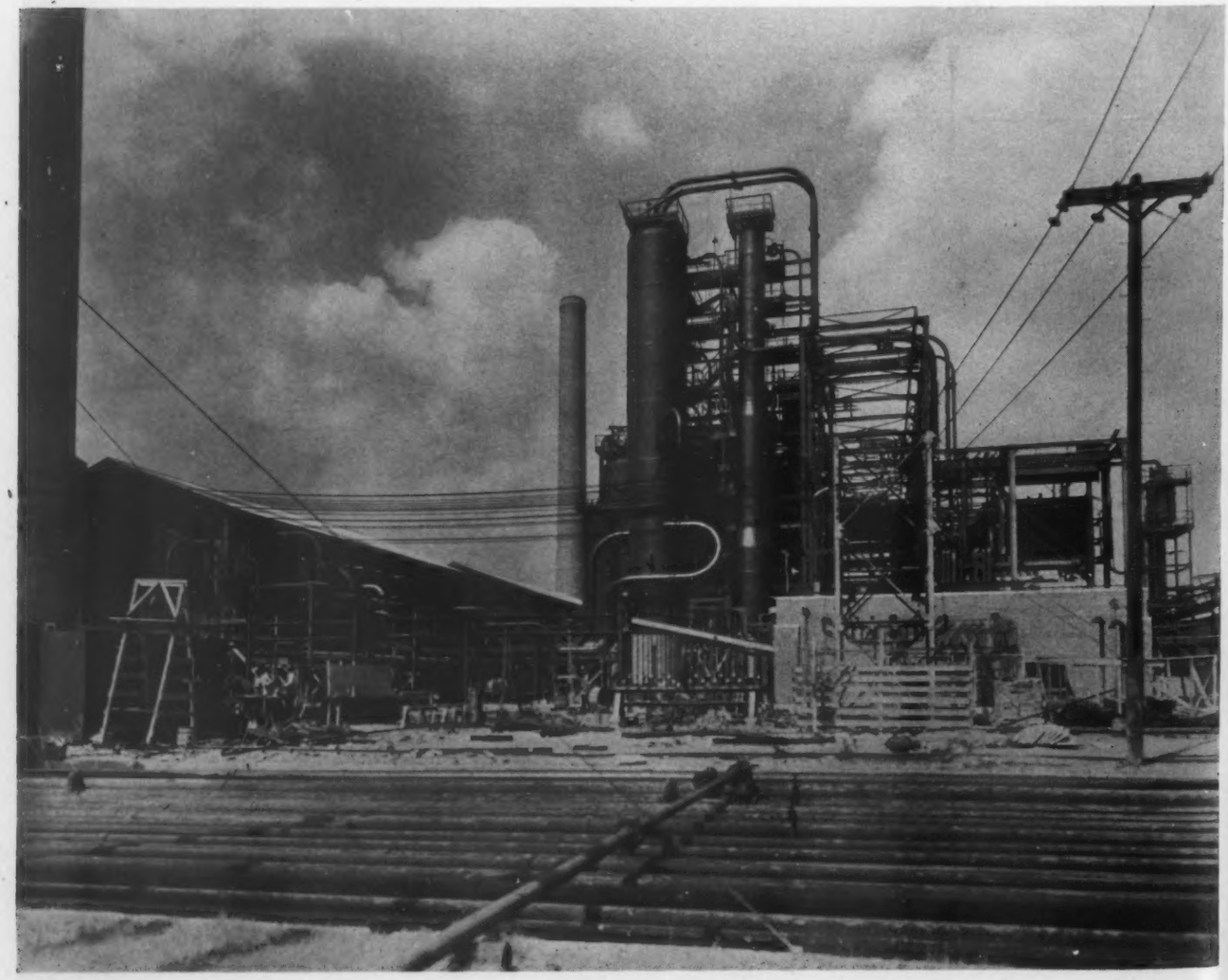
COURTESY, E. B. BADGER & SONS COMPANY

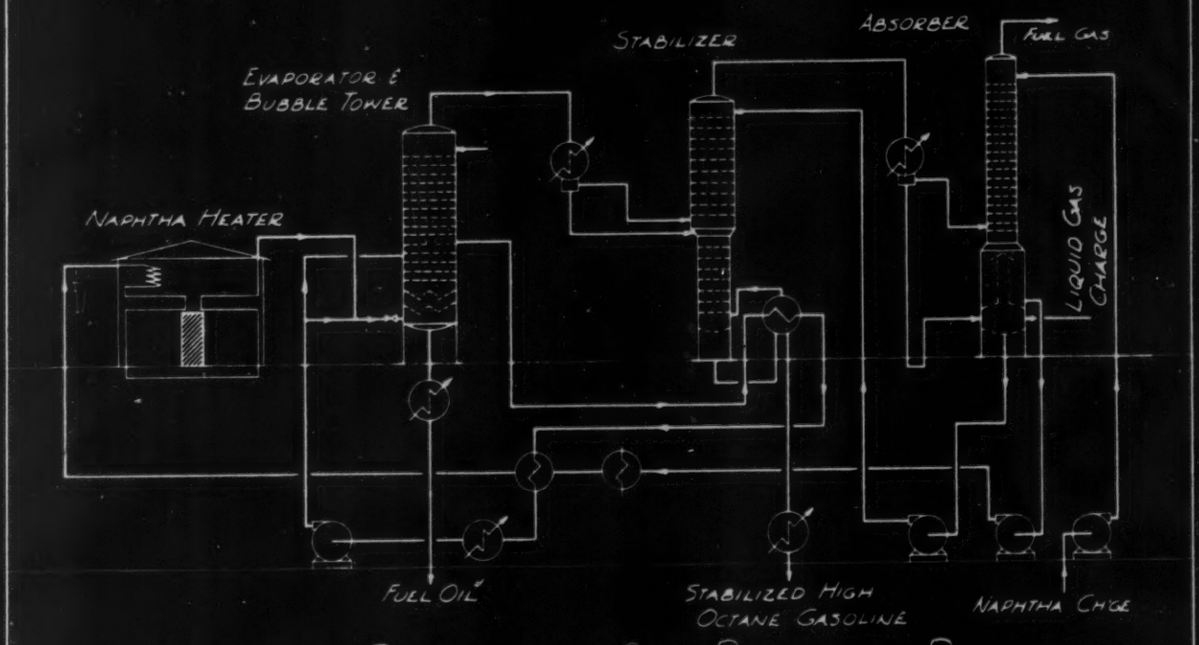
Polyform or Gas Reversion

THE LUMMUS COMPANY

UNDER the Phillips Petroleum Company and Gulf Oil Corporation patents with established practice covering a period of over four years and with 10 plants operating, The Lummus Company, 420 Lexington Avenue, New York, New York, is now building two large Polyform or Gas Reversion Plants to produce 10,000 barrels and 6,000 barrels per operating day of high octane gasoline from heavy naphtha and outside propanes and butanes. This process for the production of high octane gasoline with low specific gravity fuel gas from all cracking stocks is now available to the refining industry through The Lummus Company.

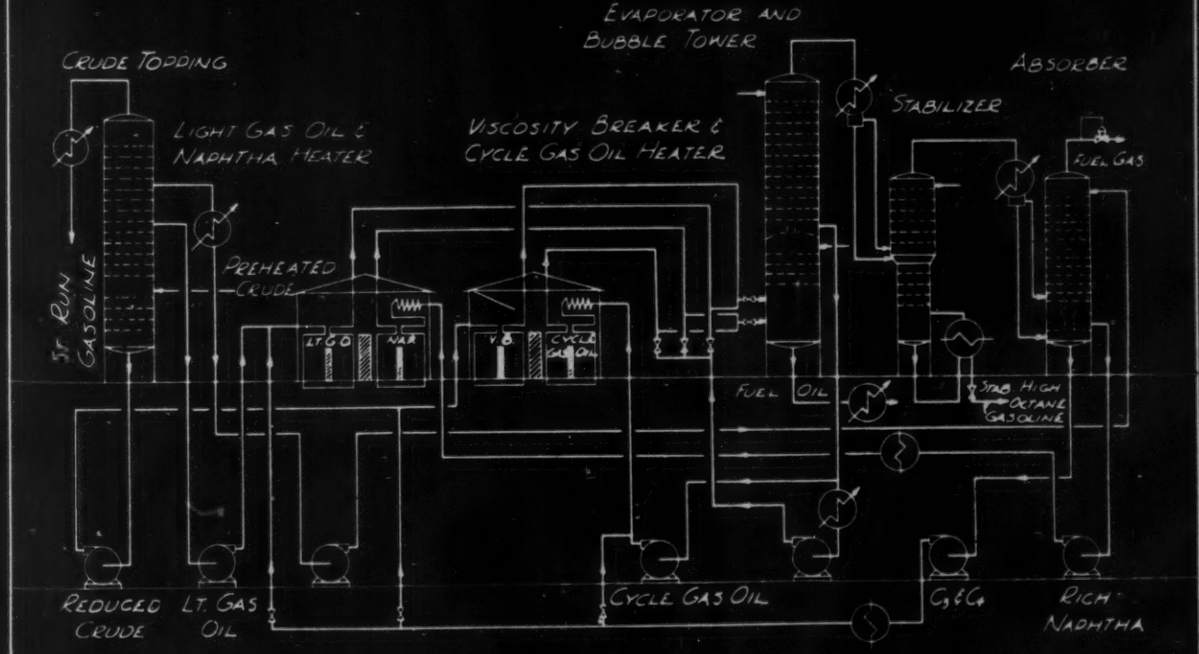
This process makes possible the production, with high yields, of a gasoline with straight line boiling range from 90 initial to 400 end point with a research octane from 88 to 95, and with exceedingly good blending values and lead susceptibility. When applied to gas oils or reduced crudes, approximately double the conversions per pass are obtained over those by conventional cracking methods. The combination of increased yields and high octane number makes this process attractive to the refining industry.





NAPHTHA POLYFORM OR GAS REVERSION PROCESS

LUMMUS POLYFORM OR GAS REVERSION



FULL CRUDE POLYFORM OR GAS REVERSION PROCESS

COURTESY, THE LUMMUS COMPANY

Perco Catalytic Desulfurization

THE Perco Catalytic Desulfurization Process provides an economical means of removing, in general, 40-60 percent of the sulfur content of cracked gasolines, 60-98 percent from straightrun gasolines, and 90-100 percent from natural gasolines. The types of sulfur compounds removed by the process include the mercaptans, sulfides, and disulfides, while the cyclic compounds are not greatly affected. The variation in quantity of cyclic compounds present in the above mentioned types of gasoline accounts for the differences in reduction of total sulfur content.

It is well recognized now that sulfur compounds in motor fuels have a very marked effect in reducing the response to tetraethyl lead, and the primary purpose of catalytic desulfurization is to eliminate this effect, although there are other important benefits in many cases, such as reduction of sulfur content to specifications, improvement in odor, and improvement in stability. The improvement in lead response is usually accompanied by an improvement in the clear octane number, and the combined effect is often sufficient to enable a fuel to be sold in the next higher price bracket.

The process operates at low pressure and moderate temperature. As shown in the flow sheet on the opposite page, the feed is vaporized—usually by heat exchange with the product leaving the catalyst tower—and then superheated to a temperature in the neighborhood of 750° F., depending on the nature of the product. The superheated vapors are passed through the catalyst bed, where the organic sulfur compounds are decomposed to hydrogen sulfide. The pressure on the catalyst tower is generally maintained at 50 pounds or less, and the flow rate may range from 100 to 300 barrels of liquid feed stock per ton of catalyst per day. After cooling and condensing the product, the hydrogen sulfide is removed by whatever means is most applicable in the particular instance, such as fractionation or chemical treatment or a combination of both.

Operating cycles up to 30 days or more for a charge of catalyst are obtained on many gasolines, which result in catalyst costs of the order of 1 cent per barrel. For treatment of products which deactivate the catalyst rapidly the process may be modified, whenever desirable, to include a regeneration operation. The catalyst can be regenerated an indefinite number of times without impairment of its activity. There is substantially no loss of hydrocarbons involved in the desulfurization treatment.

The process is especially useful in the production of aviation or premium motor fuels from straightrun gasolines, where the maximum lead response is desired. Several typical examples of the effects of catalytic desulfurization on lead response are shown below for various types of gasolines.

STRAIGHTRUN GASOLINE

58° API Gravity; 6-Lb. R.V.P.; 400° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	53.8	57.8
+1 cc. TEL	59.2	68.9
+2 cc. TEL	63.0	74.1
+3 cc. TEL	65.9	77.4
Total Sulfur	0.309	0.017
Mercaptan Sulfur	0.148	0.000

STRAIGHTRUN GASOLINE

64° API Gravity; 8-Lb. R.V.P.; 375° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	58.5	60.8
+1 cc. TEL	65.4	72.8
+2 cc. TEL	69.4	78.5
+3 cc. TEL	72.2	81.5
Total Sulfur	0.143	0.005
Mercaptan Sulfur	0.067	0.001

CRACKED GASOLINE

56° API Gravity; 9-Lb. R.V.P.; 420° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	65.7	69.1
+1 cc. TEL	70.0	75.8
+2 cc. TEL	72.4	78.0
+3 cc. TEL	74.5	79.8
Total Sulfur	0.140	0.076
Mercaptan Sulfur	0.062	0.003

STRAIGHTRUN NAPHTHA

50° API Gravity; 3-Lb. R.V.P.; 440° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	45.4	49.6
+1 cc. TEL	52.0	59.8
+2 cc. TEL	56.6	66.8
+3 cc. TEL	59.8	70.5
Total Sulfur	0.323	0.053
Mercaptan Sulfur	0.119	0.002

NATURAL GASOLINE

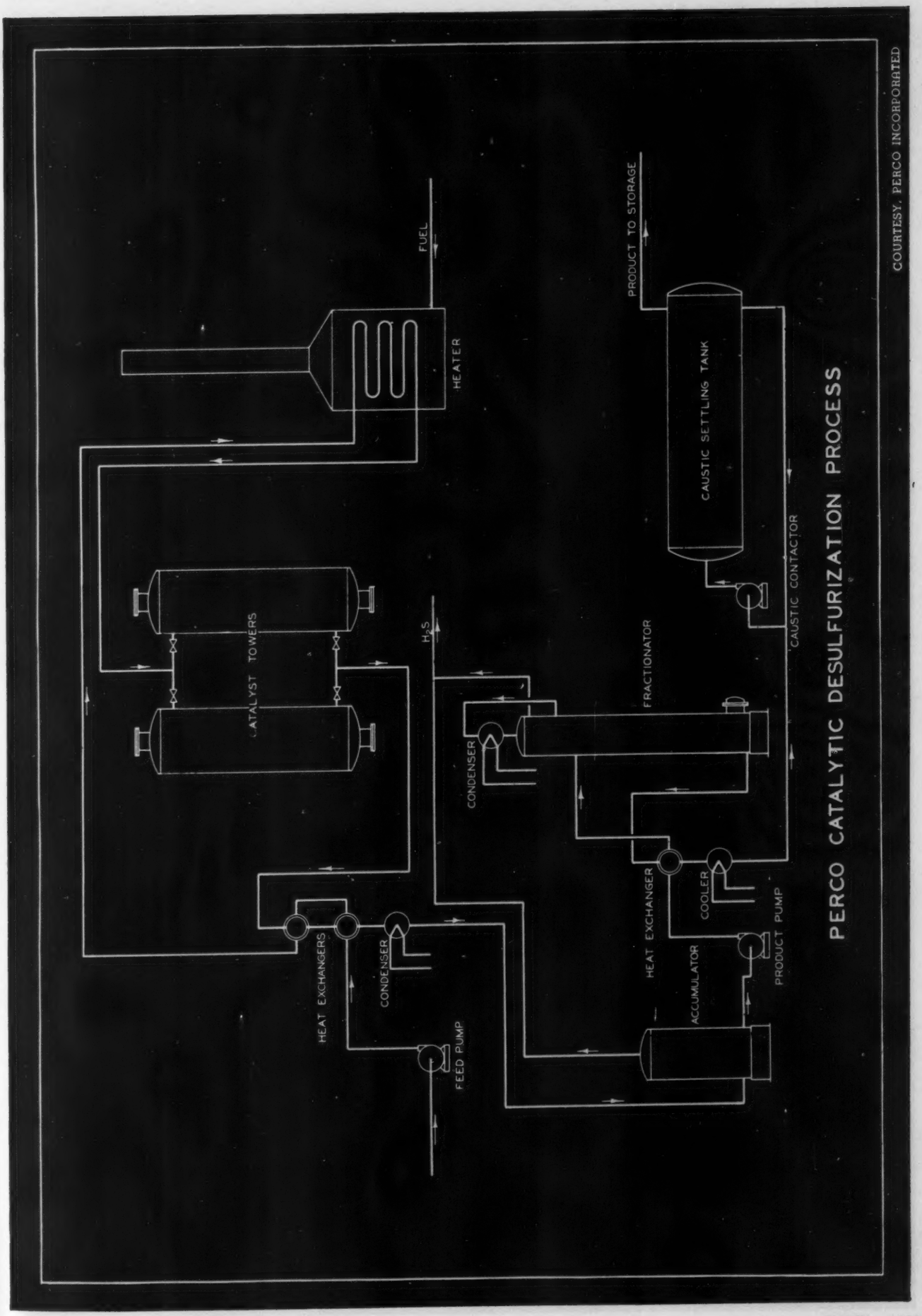
74° API Gravity; 7-Lb. R.V.P.; 320° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	56.8	58.5
+1 cc. TEL	62.3	72.2
+2 cc. TEL	66.5	78.5
Total Sulfur	0.218	0.005

GAS WELL DISTILLATE

71° API Gravity; 12-Lb. R.V.P.; 375° F. E.P.

	Undesulfurized	Desulfurized
ASTM Octane No.	51.8	54.2
+1 cc. TEL	58.7	67.9
+2 cc. TEL	63.7	74.0
Total Sulfur	0.170	0.001


PERCO CATALYTIC DESULFURIZATION PROCESS
COURTESY, PERCO INCORPORATED
FUEL
HEATER
PRODUCT TO STORAGE
CAUSTIC SETTLING TANK
CATALYST TOWERS
H_2S
FRACTIONATOR
CAUSTIC CONTACTOR
CONDENSER
HEAT EXCHANGER
COOLER
HEAT EXCHANGERS
CONDENSER
ACCUMULATOR
PRODUCT PUMP
FEED PUMP

Perco Copper Sweetening Processes

VARIOUS methods of treating gasoline with reagents comprising compounds of copper have been suggested for many years and those enjoying present widest commercial acceptance are those which have been made available through the licensing activities of Perco Incorporated, Bartlesville, Oklahoma, and its various licensing representatives. The mounting success of the Perco processes is shown by the installation in the last year of 21 additional units, so that there are now installations in 111 plants belonging to 59 licensees, in the United States, Canada, Europe, South America and Africa.

The processes take advantage of the oxidation of mercaptans by cupric chloride, and the subsequent regeneration of the copper chloride with oxygen as shown by the equations:

(1) $2\,RSH + 2\,CuCl_2 \longrightarrow RSSR + 2\,CuCl + 2\,HCl$
Mercaptan + Cupric Chloride → Disulfide + Cuprous Chloride + Hydrochloric Acid

(2) $2\,CuCl + 2HCl + \tfrac{1}{2}\,O_2 \longrightarrow 2CuCl + H_2O$
Cuprous Chloride + Hydrochloric Acid + Oxygen → Cupric Chloride + Water

(1) + (2) $2\,RSH + \tfrac{1}{2}\,O_2 \longrightarrow RSSR + H_2O$
Mercaptan + Oxygen → Disulfide + Water

As shown by the equations, one of the advantages of the process is the theoretical absence of chemical consumption in the sweetening step. In practice it is necessary only to make up mechanical losses of the treating solution, and chemical costs have frequently been reduced to less than 10 percent of the expenditure required by the older methods. Other operating charges are reduced, particularly labor costs, because of the simplicity of the method.

The elimination of gasoline loss, due to treating in a closed system and complete separation from the treating solution, contributes substantial savings. Probably the most important item is the improvement in quality of the copper treated product. The usual loss in octane number incurred in sweetening with lead compounds is eliminated, with consequent savings in tetraethyl lead requirement. The product is also more responsive to gum inhibitors, if these are used; without gum inhibitors the various gum tests are usually improved. The product is unusually stable when exposed to sunlight, with respect to both color and to corrosion test. All of these effects are due to the absence of the deleterious higher alkyl polysulfides (trisulfides, tetrasulfides, etc.) to which the mercaptans are partially converted, along with the desired disulfides, in other sweetening methods. Copper sweetening can form only the disulfides, since no additional inorganic sulfur is present in any form during the reaction. In the treatment the sulfur content is, of course, unchanged.

The Perco process is applicable to any stock requiring sweetening and is especially suitable for those of a very sour nature since these are handled with only a slightly higher cost due to increased air requirements. This method of sweetening is applied in two ways; if the stock to be treated is sufficiently stable to color and gum when treated in presence of air, it is mixed with the necessary air and filtered through a bed of absorbent material impregnated with the copper reagent; other stocks are continuously treated with the copper solution in the absence of air and the copper regenerated in a separate tank. The oxidizing power of the solution is controlled to prevent side reactions with unstable hydrocarbon constituents. Stocks treated with the copper solution are given a final sodium sulfide wash to give color and gum stability, by removing minute traces of copper which are present in the treated oil.

The simplified flow diagrams on the opposite page illustrate the two methods. In either process, if the gasoline to be sweetened contains hydrogen sulfide or free sulfur, these compounds are removed by a caustic washing step prior to the sweetening operations. If hydrogen sulfide and free sulfur are not present, as is often the case, this step may be omitted.

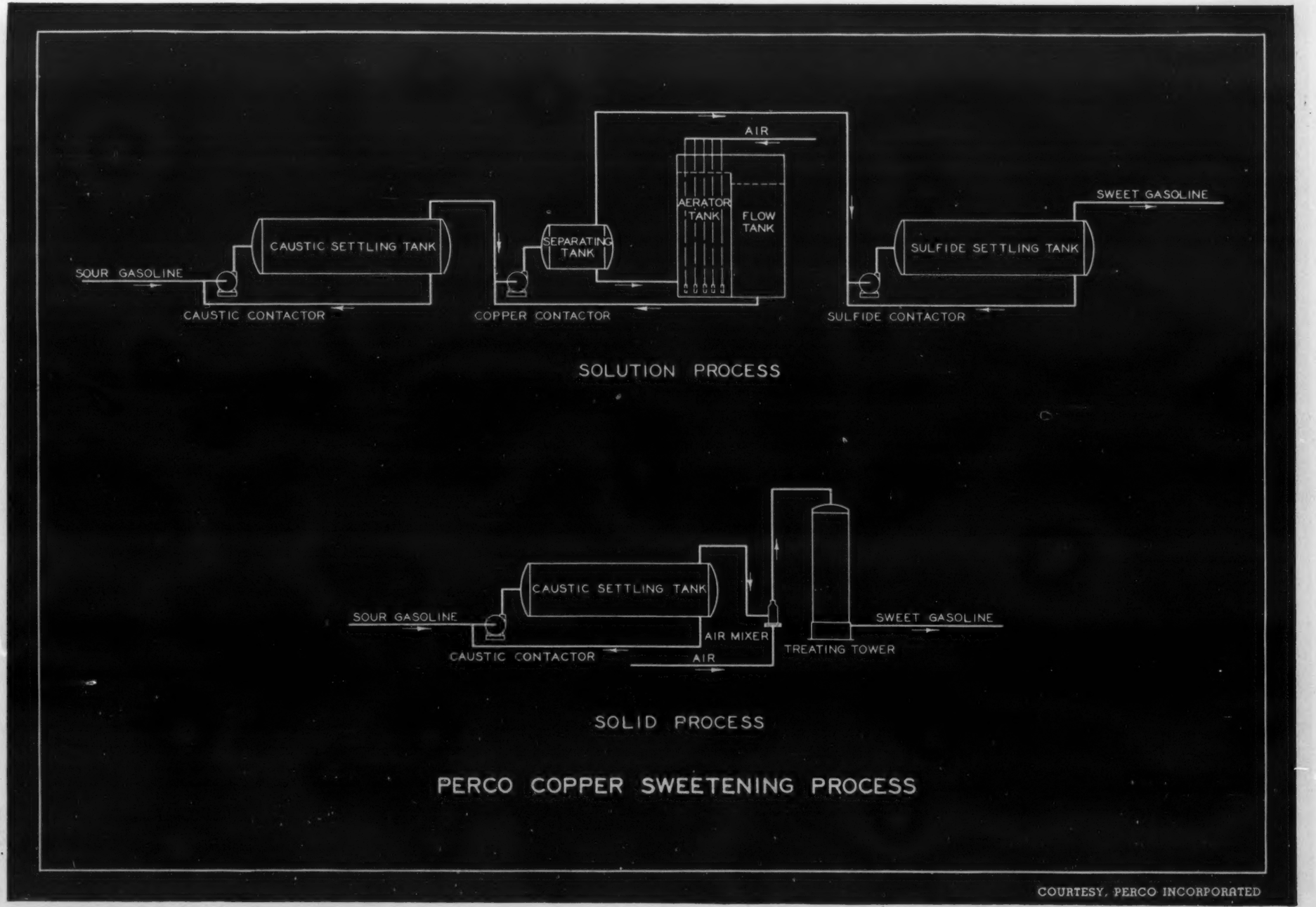
In the Perco solution process, the gasoline is continuously treated by contacting with the treating solution in a centrifugal pump. The mixture of copper solution and sweetened gasoline passes to a separating tank, from which the used copper solution is continuously withdrawn to the regenerating tank where it is regenerated with a controlled amount of air to give the desired oxidation potential. The maximum efficiency of the air is obtained by diffusers, as illustrated. The regenerated copper solution overflows to a solution storage tank and is then recycled. The sweetened gasoline is continuously withdrawn from the top of the separating tank and is given the final stabilizing wash, settled, and passed to finished storage. In the solid process, the stock free of hydrogen sulfide is mixed with a predetermined quantity of air, which is dissolved in the gasoline, filtered through the reagent and passed to finished storage.

In the Perco solution process all equipment in contact with the copper solution is constructed of corrosion resisting material, as the solution is corrosive to iron or steel. In the solid process ordinary materials are used throughout.

Due to compactness of equipment and relatively small size for a given throughput, the total installation costs are low even though part of the equipment is relatively expensive. The cost of a Perco Copper Sweetening unit is approximately that of the older types used.

The following example of liquid treatment of a cracked distillate having a 170-400° F. boiling range and 53° A.P.I. gravity is typical of results obtained in comparison to doctor treating.

	Sour	Doctor Treated	Perco Treated
Color, Saybolt	+2	−5	+2
Color, Stability	0	−16	+1
Octane Number			
Without lead	62.9	61.9	62.9
+1 cc TEL	68.5	67.8	68.5
+2 cc TEL	71.7	71.0	71.7
Induction Period, Min.			
Without inhibitor	130	130	180
With 0.002% inhibitor	320	190	415
With 0.004% inhibitor	485	305	640
ASTM Gum	2.6	0.4	0.0


AIR
AERATOR TANK
FLOW TANK
SWEET GASOLINE
CAUSTIC SETTLING TANK
SEPARATING TANK
SULFIDE SETTLING TANK
SOUR GASOLINE
CAUSTIC CONTACTOR
COPPER CONTACTOR
SULFIDE CONTACTOR
SOLUTION PROCESS
CAUSTIC SETTLING TANK
SOUR GASOLINE
AIR MIXER
SWEET GASOLINE
TREATING TOWER
CAUSTIC CONTACTOR
AIR
SOLID PROCESS
PERCO COPPER SWEETENING PROCESS
COURTESY, PERCO INCORPORATED

Pure Oil Thermal Polymerization

THE Pure Oil thermal polymerization process for the utilization of normally gaseous hydrocarbons in the production of high octane motor fuel blending stock has been under development for over twelve years. At the present time there are seven commercial installations employing this process and an eighth large plant now under contract. These units range in capacity from 100 to 4000 B/D of liquid hydrocarbon feed. The Lummus Company, 420 Lexington Avenue, New York, N. Y., has been authorized to design and install these plants.

Gaseous hydrocarbons derived from refinery cracking installations having varying proportions of olefins and those derived from natural gasoline or crude stabilization operations may be employed as charging stocks. In general, hydrocarbons in the boiling range of propane and butane comprise the charge to these plants.

The flow sheet opposite provides a simplified description of the process. The fresh feed is obtained from a recovery system which will vary in its design with the source of gas supply and may be interconnected with the polymerization plant recycle gas recovery. If the fresh feed is obtained from the recovery system as a liquid, it is usually pumped directly to the furnace feed tank which is held at a pressure corresponding to the vapor pressure of the furnace feed. The balance of the furnace feed (recycle) is recovered by fractionation and absorption from the furnace outlet products. The furnace feed is usually pumped through heat exchange to the heating coil and thence to the reaction coil where the temperature gradient is carefully controlled. The heat absorption in the reaction coil will be a function of the olefin content of the feed stock, but is never large, and is usually very small. The conversion products leaving the reaction coil are cooled by quench and then flow into the polymer flash tower where they are separated into a tar-free overhead containing some gasoline fractions and a tar bottoms also containing some gasoline, together with a small amount of lighter materials. The overhead is condensed and fractioned into recycle furnace feed and propane-free bottoms containing sufficient butane to meet vapor pressure requirements in the stabilizer. The polymer flash tower bottoms flow to the tar flash tower where all of the propane and a considerable proportion of the gasoline are flashed, this overhead flowing directly into the stabilizer. Any gases not condensed with the polymer flash tower overhead or the stabilizer overhead flow to an absorber where additional recycle is recovered in the absorber oil stripper. The overhead from the rich oil flash tower is condensed and flows directly into the furnace feed tank. Provision is usually made for elimination of methane from the polymer flash tower overhead by flashing at reduced pressure to prevent the methane content of the feed from becoming undesirably high.

The polymer liquids withdrawn from the stabilizer and the tar flash tower are combined and fed into the polymer distillate fractionator where a separation is made into specification polymer gasoline and tar bottoms. The polymer gasoline has excellent volatility, octane number and lead susceptibility characteristics and can readily be treated with clay or acid for gum and color stabilization.

Typical physical tests on this distillate are tabulated herewith:

Gravity, ° API	59-61
IBP, ° F.	95
10%	120
50%	170
90%	290
FBP	400
Octane number, CFRM	80-81
Reid Vapor Pres. lbs./sq. in.	9

The heating coil and reaction coil are in a common setting and are so designed that the conversion is accomplished at a relatively low and constant temperature. Reaction coil outlet temperatures will be slightly in excess of 1000° F. depending upon the feed stock, with moderate outlet pressures.

Yields ranging from 55 to 70 percent by weight of total polymer based on the propanes and butanes in the fresh feed are obtained, depending upon the ratio of propanes to butanes and the degree of saturation. The total polymer will usually contain approximately 90% of 400 end point polymer gasoline.

The yields are such that the process is economically attractive to most refiners with payouts usually ranging from one to one and one-half years depending upon the method of evaluating the charging stock. Operating and utilities costs are low for this type of operation and add to the attractiveness of this process.

PURE OIL THERMAL POLYMERIZATION PROCESS
COURTESY, THE LUMMUS COMPANY
RESIDUE GAS
ACCUMULATORS
ABSORBER OIL STRIPPER
ABSORBER
FLASH TOWER
REBOILER
STEAM
E. P. POLY DISTILLATE
FRACTIONATOR REBOILER
TAR
TAR FLASH
ACCUMULATORS
STABILIZER REBOILER
POLYMER FLASH TOWER
HEATING COIL
REACTION COIL
HEATER
FEED TANK
RECOVERY UNIT
FRESH FEED

Sharples Dewaxing Process

THE SHARPLES PROCESS of centrifugally dewaxing lubricating oils has been in commercial operation for twenty years, during which time over fifty plants have been put into operation in this and several foreign countries.

This process was originally developed for the separation of amorphous waxes from residual and heavy overhead stocks. It has always been considered the simplest and most economical method of dewaxing. In the past year the Sharples Process has been the subject of further research, and as a result a new technique has been developed which further strengthens the economic claims of this method of dewaxing.

The new development makes possible increased yields of dewaxed oil in existing plants and maximum yields of dewaxed oil in new installations. No special solvent is required other than the naphtha, present in any refinery, and normally used in the Sharples Process. The new technique also lends itself readily to the production of high melting point waxes. In all cases the addition to an existing plant can be made with little or no interruption to present operation.

The new technique involves the recentrifuging of the petrolatum from the normal dewaxing operation. It reduces the amount of naphtha used for primary separation so that the maximum requirements are two parts of naphtha to one of stock. The petrolatum produced as a result of the primary operation is then diluted with approximately half of the naphtha that is used in the primary operation, equivalent to a dilution ratio of five or six parts of naphtha to one of the primary petrolatum, and recentrifuged for oil recovery. The recovered oil solution coming from the secondary operation is then used as a dilution makeup for the primary operation. Thus the process permits the use of the minimum amount of dilution at the point where cold test and cloud are being made and the maximum amount of dilution at the point where the oil is being recovered from the petrolatum for increasing yield. The total amount of naphtha needed for the complete dewaxing operation is not increased but is frequently decreased.

In an existing plant where it is desired to add the secondary operation the present plant need not be disturbed except for the final "tie-in" of the secondary system unless it would be profitable at the same time to change the chilling system so that a maximum of refrigeration could be recovered by exchange. The incorporation of such savings in refrigeration minimizes the additional refrigeration requirements for the added secondary operation and often enough saving of refrigeration can be effected to completely take care of the secondary operation.

In a new plant the primary operation would consist of a small blend tank where the stock and naphtha are blended in approximately a 1:1 dilution. This solution is pumped through a vertical exchanger chilling tower where it is chilled by dewaxed oil solution to about 85° F. At this point the recovered oil dilution is added and the chilling in full dilution is continued further by exchange and finally by direct expansion ammonia to the required centrifuging temperature. From the chillers the cold solution is fed at constant pressure to the primary centrifuges where it is separated into dewaxed oil and primary pet.

The dewaxed oil on its way to the naphtha reduction unit, is pumped continuously through the exchanger chilling tower system for maximum recovery of refrigeration.

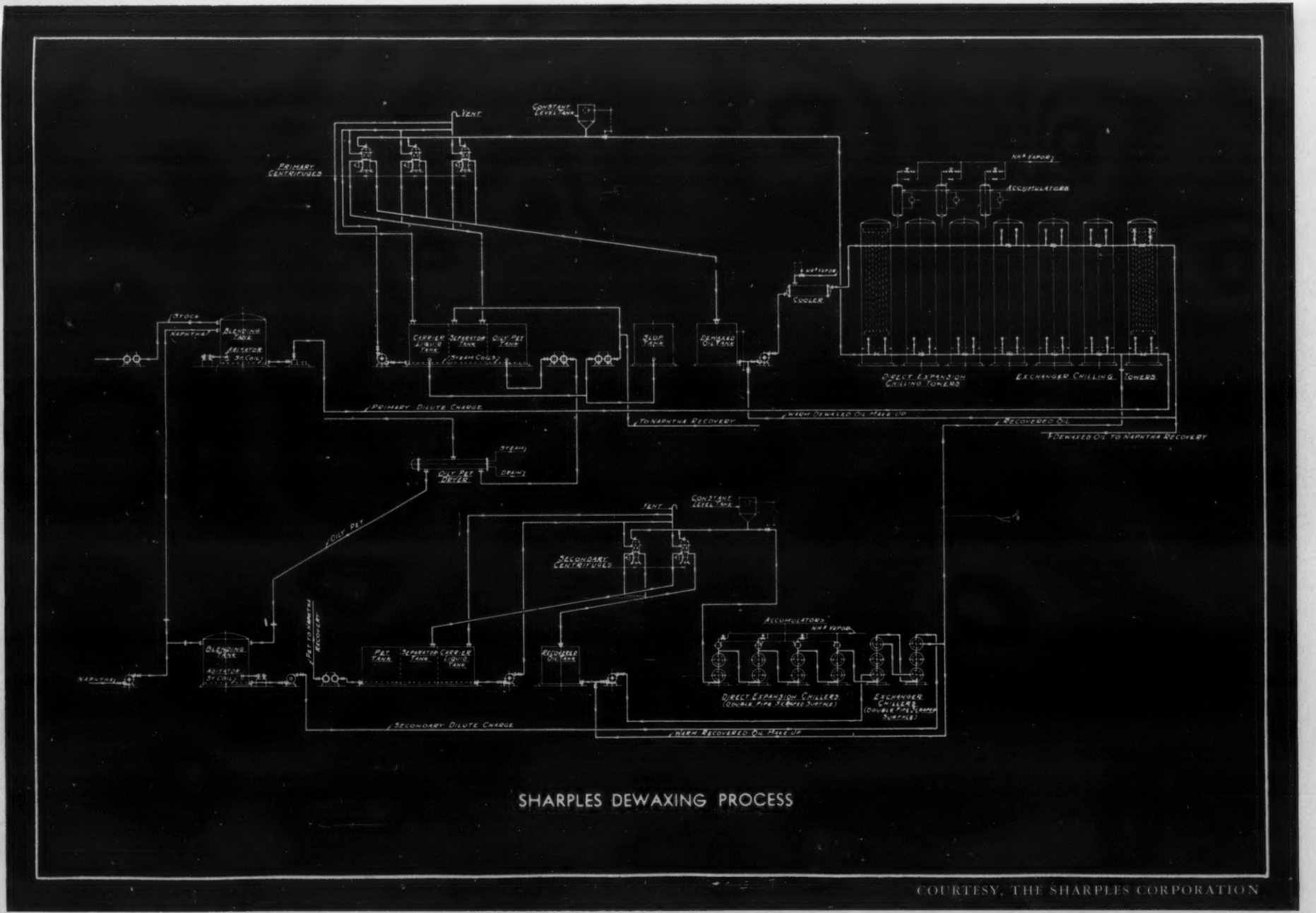
The oily pet should preferably be dehydrated by partial or complete removal of the naphtha in order to eliminate ice in the chilling system. If it is desired to separate high melting point wax this moisture removal step will be unnecessary in that the moisture will be removed in the high temperature centrifuging stage. The primary oily pet is blended with five or more volumes of naphtha, equivalent to approximately one half of the primary dilution requirements. This blend is then rapidly chilled to the same temperature under which the primary centrifuging was carried out by pumping through large diameter double pipe scraped surface exchanger chillers and similar type direct expansion chillers. The cold solution is then fed at constant pressure to the secondary centrifuges where it is separated into recovered oil and petrolatum.

The recovered oil is passed continuously through the secondary exchanger chillers enroute to enter the primary chilling system as described previously.

To add still further to the economy of the process a new Sharples D-4 centrifuge has been perfected which has four times the capacity of the centrifuge previously furnished for this service. This new centrifuge can be utilized in either primary or secondary service.

In installations where conditions warrant it, the secondary system may be varied to produce high melting point waxes. The melting point of the wax depends entirely upon the nature of the stock and the temperature at which they are separated. Thus to provide for this step it would only be necessary to bleed out of the secondary chilling system at any desired temperature, and centrifuge. The high melting point wax is recovered from the system and the remaining low melting point wax returned to the chilling system at the same point from which it was originally removed for further chilling to the temperature of the normal secondary operation for recovery of oil.

This description of the Sharples Process and the flow chart on the opposite page are presented through the courtesy of The Sharples Corporation, Twenty-third and Westmoreland streets, Philadelphia, Pennsylvania.



SHARPLES DEWAXING PROCESS

COURTESY, THE SHARPLES CORPORATION

Shell Phosphate Process

THE Shell Phosphate Process is a regenerative liquid purification system for the removal and recovery of hydrogen sulfide from gaseous and liquid hydrocarbons. The process consists essentially of two steps: absorption or scrubbing with a solution of tripotassium phosphate and regeneration of the spent solution. The principal absorption reaction is expressed

$$H_2S + K_3PO_4 \text{ —— } KHS + K_2HPO_4.$$

Regeneration reverses this reaction.

The hydrogen sulfide recovered is essentially free of hydrocarbons and is an ideal raw material for the manufacture of sulphuric acid or elemental sulphur.

The inexpensive solution used is ordinarily prepared at the plant from commercial grades of potassium hydroxide and phosphoric acid in such proportion that the molal ratio of KOH to H_3PO_4 is between 2.95 and 3.00 to 1. The optimum concentration of K_3PO_4 depends upon the amount and nature of impurities in the hydrocarbon processed. Since K_3PO_4 is a stable inorganic salt, which does not decompose nor vaporize under treating conditions, solution loss is negligible, being confined to leakage at packing glands of pumps, etc. Such leakage can be collected and returned to the system. K_3PO_4 does not contaminate nor polymerize the hydrocarbon.

Iron and steel are satisfactory for all equipment. In case of corrosive cooling-water, Admiralty-metal tubes and Muntz-metal sheets and baffles may be used for condenser and solution cooler. Gages, instruments, valves and pumps should be all iron and steel. Monel or stainless-steel trim can be used. Observance of these general specifications will insure freedom from corrosive troubles on the process side.

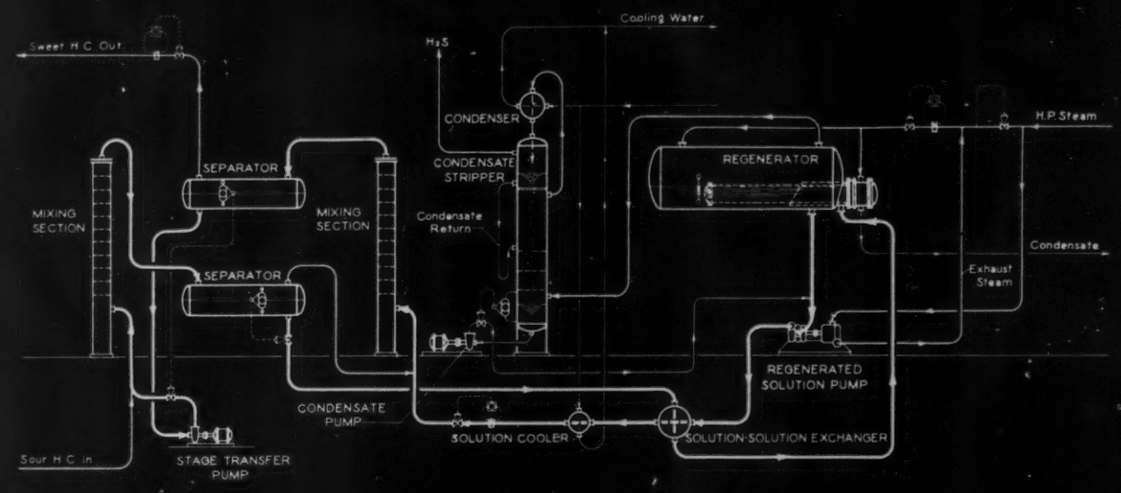
The accompanying flow diagrams indicate the necessary equipment. Gases are scrubbed in a countercurrent absorber of bubble-plate or packed-tower construction. The hydrogen-sulfide content of gases can be reduced low enough to satisfy any reasonable refinery requirement. Treatment at temperatures as high as 200° F. is possible with the Phosphate Process. The equilibrium vapor pressure for a given solution saturation is appreciably less over dilute than over concentrated solutions. Advantage is taken of this property of phosphate solution by using a split solution flow in the absorber. The bulk of the H_2S is absorbed in the lower section with full strength K_3PO_4, and the more difficult removal of the last traces of H_2S is done in the upper section by a relatively dilute solution composed of all condensate and a small portion of regenerated solution.

Equilibrium of tripotassium phosphate with liquid hydrocarbons is even more favorable than with gases. A hydrogen-sulfide content of treated propane-butane mixtures as low as 0.005 mol percent is not unusual. Liquid phase contact sections may be of two types: a countercurrent packed tower or a series of mixers and settlers arranged for countercurrent flow. The split solution flow principle is applicable also to liquid phase extraction.

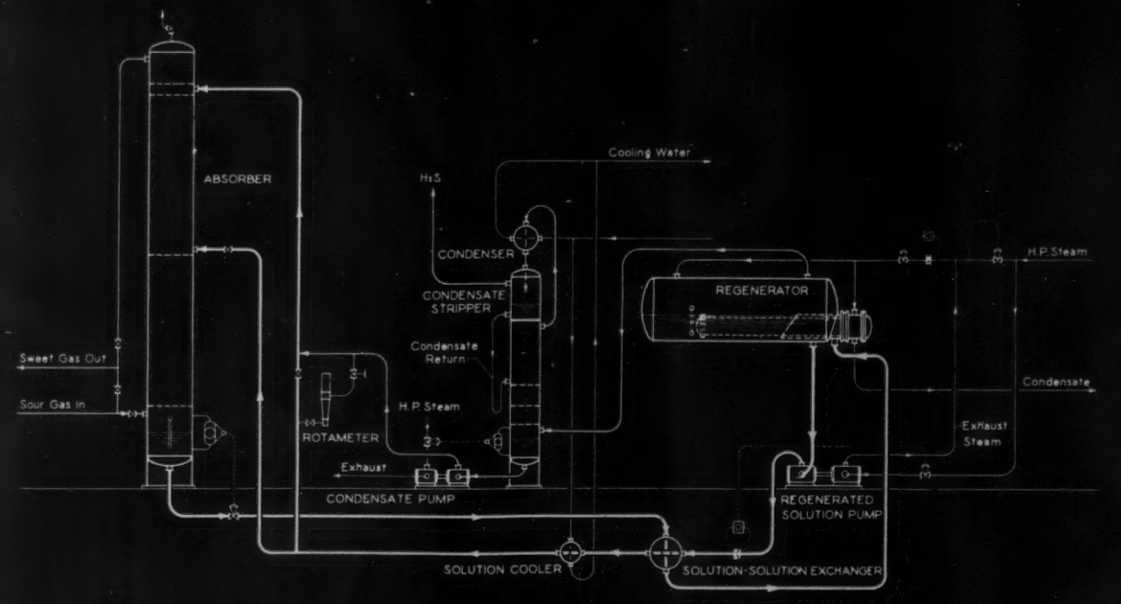
Regeneration of spent solution is ordinarily accomplished in a standard reboiler which can be heated with exhaust or other low pressure steam. The vapor evolved, H_2S and steam, is condensed and cooled; the condensate is stripped and returned to the top of the absorber or to the regenerated solution direct to maintain proper concentration; and hydrogen sulfide is vented to special usage or suitable disposal. The concentrated solution falls by gravity to a surge tank where residence at the boiling point causes further regeneration. Heat economy is realized through use of exchangers on the solution to and from the reboiler. A final cooler lowers the temperature of the solution returned to the absorber. Direct-fired regeneration is also possible in this process. Thus a phosphate plant can be installed without increasing existing steam generation facilities. Stripping with steam is another successful method of regeneration.

Operating and maintenance costs are low. Full automatic control is possible, so that only part of an operator's time is required for general supervision. Occasional laboratory analyses serve to indicate proper operation. As was mentioned above, corrosion problems are practically non-existent.

The process is licensed by Shell Development Company, San Francisco. Shell Development Company furnishes special instructions for preparing the solution and operating the plant, including a detailed discussion of analytical methods for chemical control.



SHELL PHOSPHATE PROCESS, △ LIQUID PHASE



SHELL PHOSPHATE PROCESS △ VAPOR PHASE
[SPLIT SOLUTION FLOW]

COURTESY, SHELL DEVELOPMENT COMPANY

Regenerative Mercaptan Removal

SHELL DEVELOPMENT COMPANY

THE continuous extraction of mercaptans from gasoline with aqueous caustic soda and the regeneration of the spent solution for reuse has been developed into a process* that is being extensively employed in the petroleum refining industry.

When applied to sour gasolines the process removes only the more reactive of the mercaptans and must be followed by doctor or other sweetening treatment if a sweet product is desired. Nevertheless, it has definite merits in that its application reduces the sweetening costs.

The accompanying flow diagram shows a typical installation for treating gasoline containing hydrogen sulfide in addition to mercaptans. Since hydrogen sulfide reacts with caustic soda to give sodium hydrogen sulfide or sodium sulfide, which cannot be readily hydrolyzed into NaOH and H_2S, it becomes necessary to remove H_2S prior to mercaptan extraction. Usually a single-stage contact with a relatively dilute caustic is sufficient. The spent caustic from this pretreatment is discarded or utilized, depending on circumstances.

In most cases, H_2S will already have been removed in stabilizers.

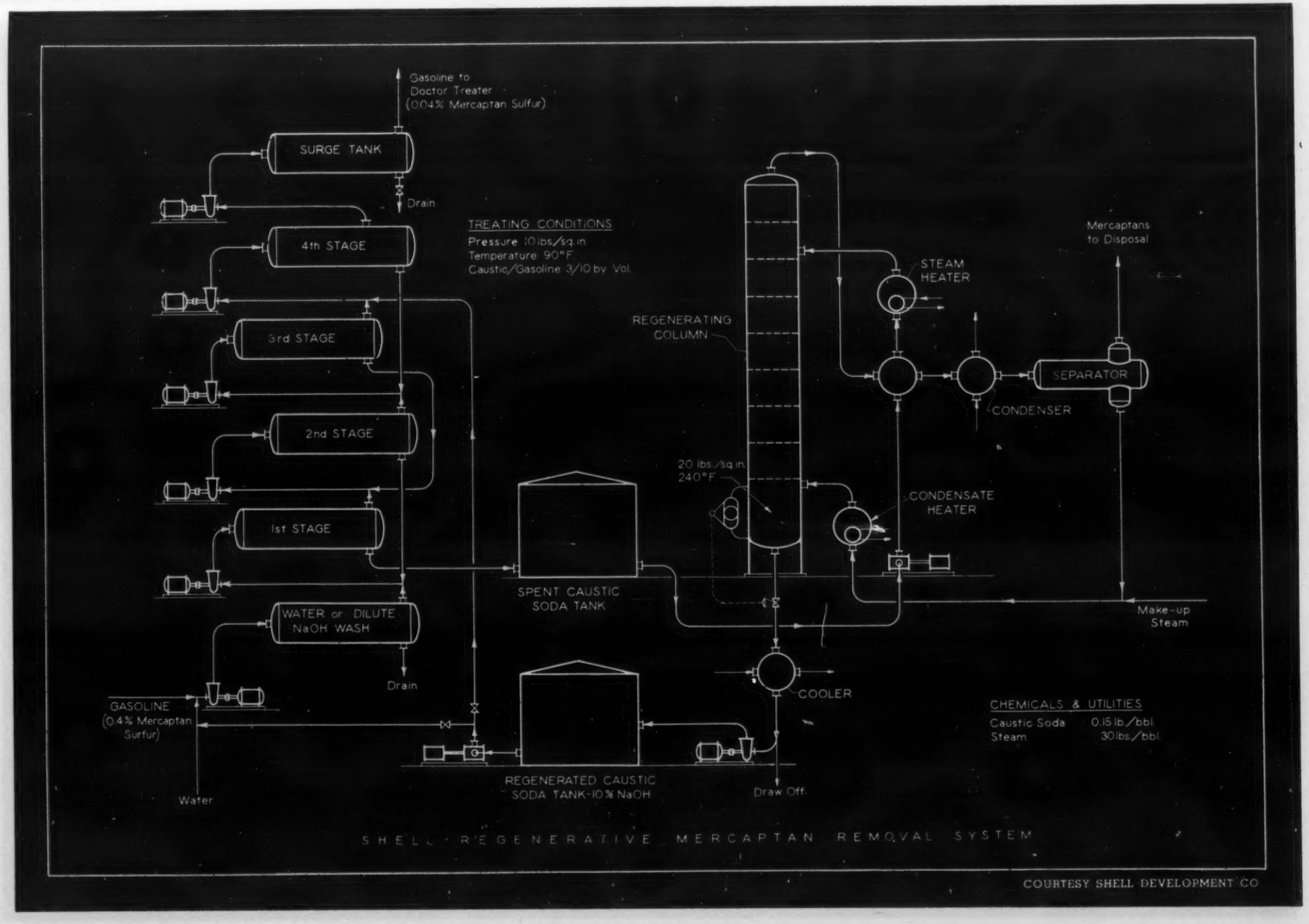
The H_2S-free gasoline is extracted in a countercurrent system with a caustic soda solution that reacts with mercaptans and removes them from the gasoline. Either a column packed with caustic-resistant rings, such as carbon rings, or a series of several mixing-settling stages are used for this purpose. The treated gasoline, with its content of mercaptans much reduced, is then subjected to the final sweetening treatment. The fat caustic solution containing sodium mercaptides and contaminated, in some cases, with the reaction products of other acidic impurities of the sour gasoline is charged to the regenerating section of this process.

The regeneration of the caustic solution consists of heating the solution containing mercaptides to cause their hydrolysis and stripping the mercaptans from the solution with steam. The stripping is carried out in a conventional bubble-plate column, the steam required being generated in a reboiler. The stripped caustic is passed through a cooler and returned to the extraction stage of the process. The mixture of steam and mercaptans leaving the stripper is cooled by heat exchange with the incoming fat solution and condensed. The condensed mixture is settled in a decanter, from which the steam condensate is drained and mercaptans drawn off for disposal. Surge tanks are usually provided for the fat and regenerated caustic solutions, and the usual liquid level and flow controls are used.

Ordinarily, not all the acidic components of gasolines are removed by the prewash with dilute caustic or water. Those that remain react to form compounds from which the caustic cannot be regenerated and the attendant loss of caustic must be made up when analytical tests indicate a deficiency of this reagent in the solution. Obviously, the chemical cost of this process varies considerably with the distillates being treated and depends entirely on the quantity and the nature of their acidic components.

Typical operating data for the process are included on the flow diagram.

* Licensed by Shell Development Company under Rosenstein Patent No. 1,943,744.


Gasoline to
Doctor Treater
(.004% Mercaptan Sulfur)
SURGE TANK
Drain
4th STAGE
3rd STAGE
2nd STAGE
1st STAGE
WATER or DILUTE
NaOH WASH
Drain
GASOLINE
(0.4% Mercaptan
Surfur)
Water
TREATING CONDITIONS
Pressure 10 lbs./sq.in.
Temperature 90°F
Caustic/Gasoline 3/10 by Vol.
REGENERATING
COLUMN
20 lbs./sq.in.
240°F.
STEAM
HEATER
Mercaptans
to Disposal
SEPARATOR
CONDENSER
CONDENSATE
HEATER
SPENT CAUSTIC
SODA TANK
Make-up
Steam
COOLER
REGENERATED CAUSTIC
SODA TANK-10% NaOH
Draw Off
CHEMICALS & UTILITIES
Caustic Soda 0.15 lb./bbl.
Steam 30 lbs./bbl.
SHELL REGENERATIVE MERCAPTAN REMOVAL SYSTEM
COURTESY SHELL DEVELOPMENT CO

Shell Solutizer Process

THE Shell Solutizer Process for sweetening gasolines and naphthas is unique in that a doctor-sweet product is made by a substantially complete physical extraction, instead of chemical conversion, of mercaptans. For the extraction caustic solution containing an organic substance (such as potassium isobutyrate), called for brevity Solutizer, is used. The removal of mercaptans gives products characterized without exception by an improvement in their TEL susceptibility and, very often, by an improved initial octane rating, compared to those sweetened by conventional doctor or other treatments based on the oxidation of mercaptans to disulfides. In addition there is a reduction in total sulfur brought about by the Shell Solutizer sweetening which in some cases is sufficient to eliminate sulfuric acid treatment normally required to produce fractions conforming to low-sulfur specifications. In other cases, the Shell Solutizer sweetening applied prior to acid treating results in the reduction of acid requirements. If the rerunning of the doctor-sweet, acid-treated fractions is then carried out with the skin temperature in the reboiler not exceeding about 450° F., a doctor-sweet product can usually be distilled overhead. However, even when the Shell Solutizer Process is used merely as a substitute for doctor or other sweetening treatment, substantial economies and improvements in product qualities are effected.

The process is applicable for sweetening either straight-run, cracked, reformed, or synthetic fractions and its effectiveness even extends to the products boiling outside the normal gasoline range.

The Shell Solutizer Process is continuous and fully regenerative. Essentially, it consists of mercaptan extraction with a lean solutizer-solution and the regeneration of the fat solutizer-solution by boiling and stripping with steam. As indicated on the accompanying flow diagram, a sour gasoline or other hydrocarbon fraction is first pre-treated with a caustic solution of suitable concentration to remove such impurities as carboxylic and other relatively strong acids or to adjust the concentration of some acidic components, such as alkyl phenols, to permit efficient solutizer treatment. Usually a batch of caustic solution is used for pre-treating until practically exhausted. The pretreated gasoline is passed on to a countercurrent extraction unit in which it is brought into contact with a lean solutizer-solution. Extraction columns packed with carbon Raschig rings are effective and very convenient for this purpose. With a sour hydrocarbon fraction introduced near the bottom of the column and the lean solutizer-solution entering near the top of the column, the two streams are mixed and pass each other by gravity over a bed of packing. A doctor-sweet fraction and a fat solutizer-solution are withdrawn from the opposite ends of the column.

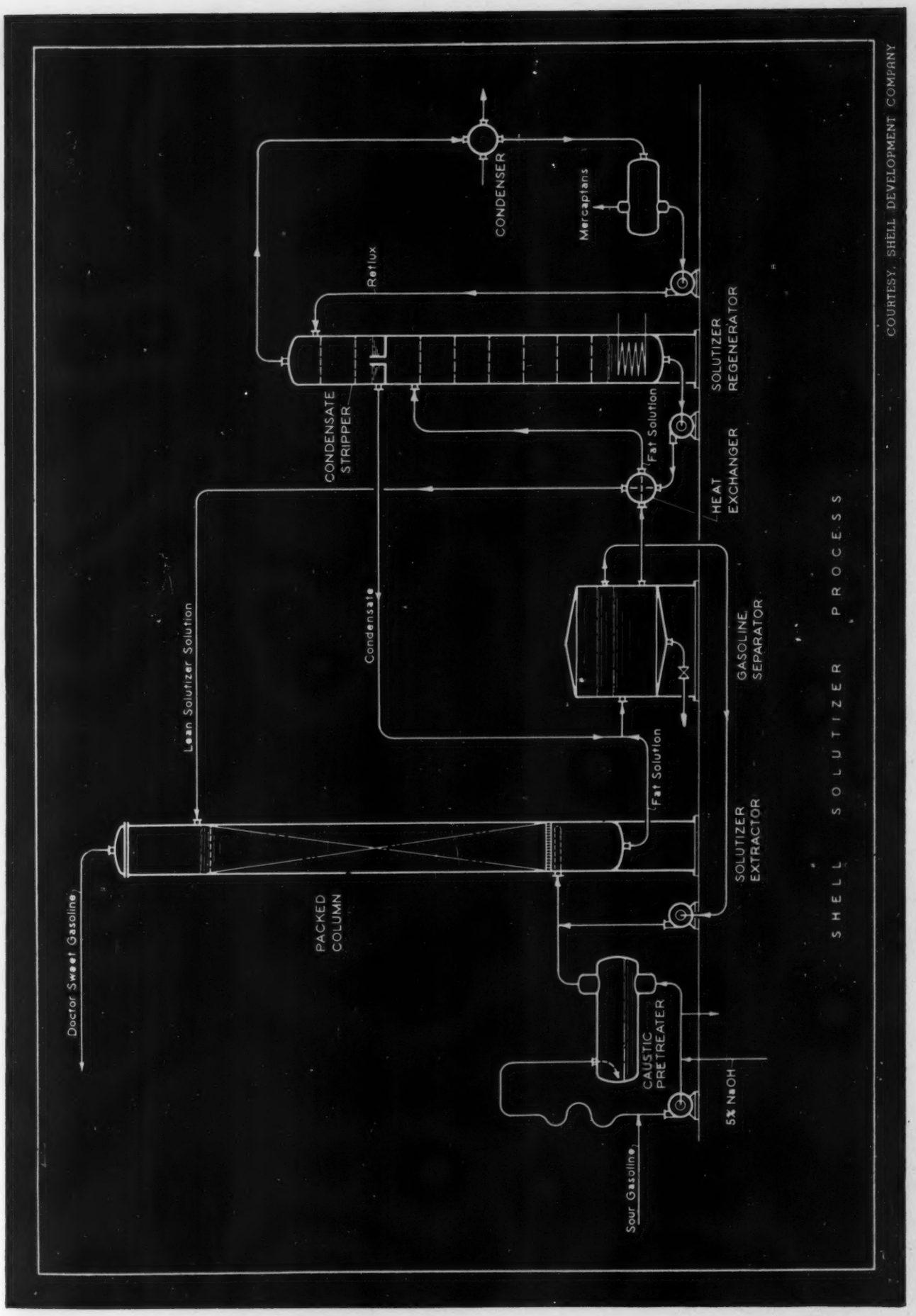
The fat solutizer-solution is then diluted with a condensate produced in the regenerating step. The diluted solution is allowed to settle in a separator, where a small quantity of sour gasoline, initially partly entrained and partly dissolved in the fat solution, separates out as the result of the dilution. This sour gasoline is skimmed and returned to the extraction column. The separated fat solutizer-solution is preheated to about 230° F. and fed to the top plate of a bubble-plate solutizer-solution regenerator. The fat solution is regenerated by being stripped of mercaptans by steam either injected from an outside source or generated in a reboiler at the bottom of the regenerator. A temperature in the neighborhood of 290° F. is maintained at the bottom of the column; it varies somewhat with the composition of the solutizer solution and the pressure. The regenerated or lean solution with a mercaptide concentration sufficiently low not to contaminate a doctor-sweet fraction in contact with it is pumped through heat exchangers and coolers to the top of the extraction column.

The steam and mercaptans pass from the regenerator to the condensate stripper and on to, first, the condenser and, then, to a separator. The condensate is pumped from the latter to the top of the condensate stripper, from which a mercaptan-free condensate is withdrawn to dilute the fat solutizer-solution just prior to the gasoline separator. The mercaptans separated from the condensate are available for chemical syntheses or can be disposed of as fuel.

The construction of the Shell Solutizer Process Plant presents no unusual engineering or corrosion problems. With the exception of a copper-nickel-alloy tube-bundle in the reboiler, the rest of the equipment can be made of low-carbon steel.

One of the developments of the basic process permits, under certain circumstances, a treatment of several gasolines to produce their doctor-sweet blend at practically no additional cost over that of the solutizer sweetening of one of the component gasolines.

The process is licensed by, and its description is released through the courtesy of, the Shell Development Company, San Francisco, California.


SHELL SOLUTIZER PROCESS
COURTESY, SHELL DEVELOPMENT COMPANY
CONDENSER
Mercaptans
Reflux
SOLUTIZER REGENERATOR
CONDENSATE STRIPPER
Fat Solution
HEAT EXCHANGER
Lean Solutizer Solution
Condensate
GASOLINE SEPARATOR
Fat Solution
SOLUTIZER EXTRACTOR
Doctor Sweet Gasoline
PACKED COLUMN
CAUSTIC PRETREATER
5% NaOH
Sour Gasoline

Sulphuric Acid Alkylation Process

ALKYLATION in its present commercial form is a process employing concentrated sulphuric acid as the catalyst to promote the alkylation of isobutane with butylenes. The importance of this process is its ability to produce greater quantities of the essentials of 100 octane aviation gasoline from the same quantity of raw materials, more rapidly and at less cost.

The process of producing 92 octane alkylate, suitable to become a component of 100 octane aviation gasoline, uses a charging stock consisting of a butane-butylene fraction of high degree of purity.

The feed stock for an alkylation plant consists of the butane-butylene fraction from a cracking or dehydrogenation operation plus additional iso-butane from natural gas. Physical characteristics of the hydrocarbons normally occurring in the feed stock are are follows:

COMPOUND	Specific Gravity	Atmos. Boiling Point ° F.	Lb./Sq. In. Vapor Pressure at 100° F.
Iso-butane	0.565	12	73.7
Iso-butylene	0.603	20	63.5
Butylene 1	0.601	21	61.5
Butadiene 1, 3	....	24	....
Normal Butane	0.585	33	52.2
Butylene 2	0.613	34 Cis. 36.5 Trans.	50.0

In order to produce crude alkylate satisfactorily it is necessary that the ratio of iso-butane to the sum of the unsaturated hydrocarbons, i.e., of iso-butylene, butylene 1 and butylene 2 shall never be less than about 1.2 by liquid volume.

The catalyst that promotes the reaction is commercial concentrated sulphuric acid of the following strength:

To the Unit	From the Unit
98.0	85—91.0

The total yield of "crude alkylate" may consist of three groups of constituents having characteristics and proportions as follows:

No. 1 Fraction		Liquid Volume Percentage
300° F. End Point Alkylate:		
Gravity, Degrees A.P.I.	70	90.0
Octane Number, C.F.R.M.	90–92	
A.S.T.M. Engler Distillation:		
10 percent	165	
50 percent	228	
90 percent	280	
Percent Recovery	98	

No. 2 Fraction		Liquid Volume Percentage
300° F. to 400° F. Alkylate:		
Gravity, Degrees A.P.I.	55.0	7.0

No. 3 Fraction		Liquid Volume Percentage
400° F. Plus Alkylate:		
Gravity, Degrees A.P.I.	43.0	3.0

This alkylate meets aviation gasoline standards with respect to acid heat, bromine number and sulphur content. Blending this product with selected straight-run aviation stock in proportion to give 86 octane number and adding 3 cc. lead gives 100 octane number C. F. R. M.

The flow sheet on the opposite page shows a typical layout of the equipment employed in the process. The plant represented here comprises the following main operating units:

(1) Alkylation mixing section which includes suitable equipment to provide the proper mixing contact and settling time.

(2) Alkylate debutanizer composed of equipment to separate between alkylate and the residual butanes.

(3) Alkylate rerun tower with suitable equipment to separate the desired 300° F. End Point alkylate, 300-400° F. alkylate, and 400° F. plus alkylate.

(4) Depropanizer tower with suitable equipment for continuous elimination of propane which is included in the charge stocks.

(5) Isobutane fractionator which is a combination of equipment to separate iso and normal butane.

(6) Dowtherm heating system which provides heat required in the preheater and reboilers.

As the olefin containing charge stock enters the mixing section, it is joined by recycle stock from the overhead of the isobutane fractionator. The combined stream is then joined by an internal recycle containing sulphuric acid and the chemical reaction begins. The reaction is exothermic and provision must be made to dissipate the heat evolved. To eliminate the heat generated by the chemical reaction, the mixture is passed into a chiller, then enters the reactor in which a suitable pressure drop is maintained in order to keep the liquid in a homogeneous state.

Leaving the reactor the stream is split in two directions. A portion passes into the suction of the recycling pump where it is joined by a portion of spent acid, a portion of fresh sulphuric acid, and the combined hydrocarbon stream described above.

The remaining portion of the stream leaving the reactor enters a separator where the acid and hydrocarbon phases are separated, with the acid at the bottom. Most of the acid is returned into the suction of the circulating pump while a small part of the acid is withdrawn from the system.

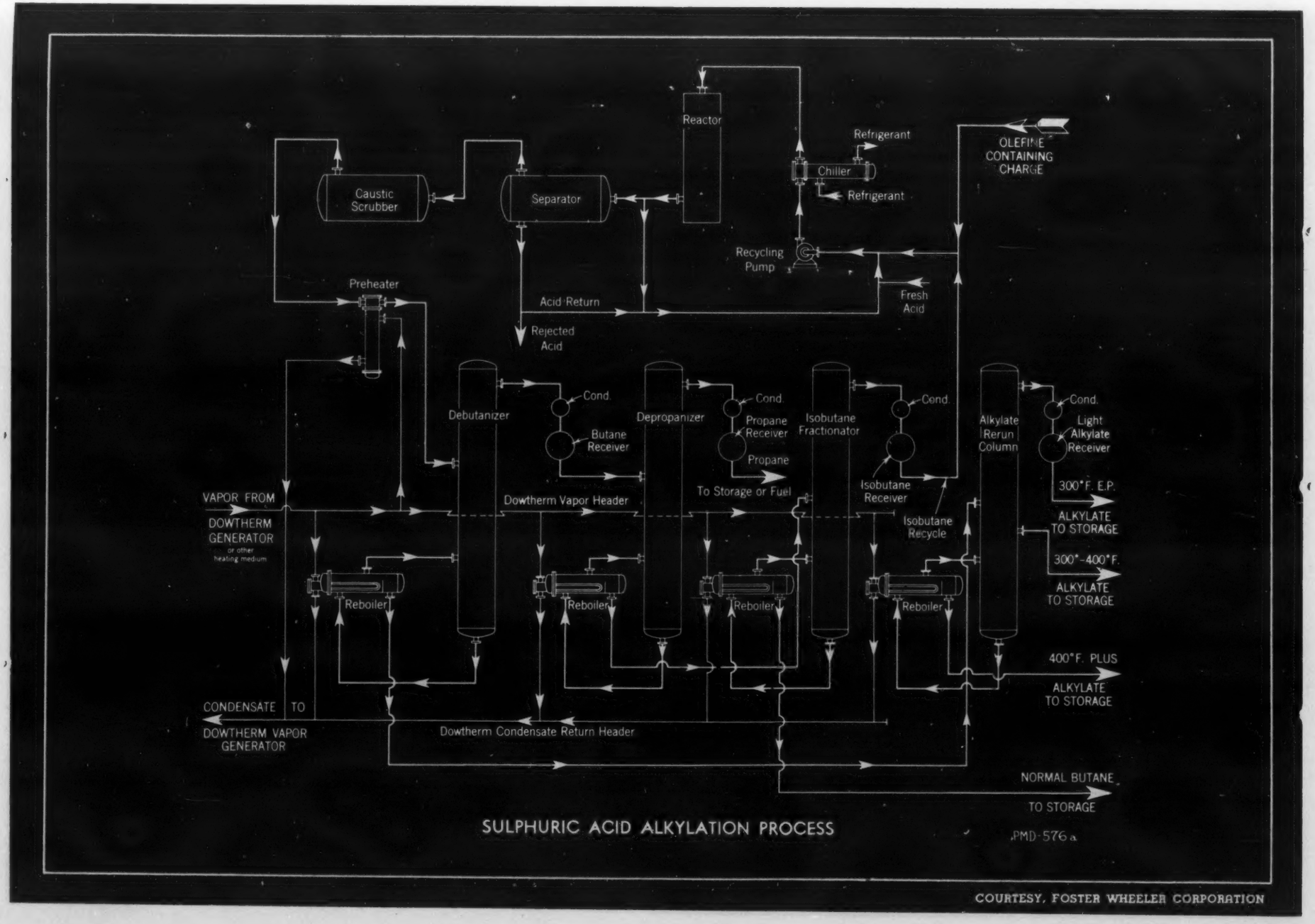
Crude alkylate is withdrawn from the separator and washed with caustic soda in a scrubber in order to counteract any acidity caused by a possible acid carry-over.

The neutralized crude alkylate containing excess butanes is withdrawn and sent to the debutanizer. The overhead from the debutanizer consists of isobutane, normal butane and any propane that may have been present in the original charge. The overhead is totally condensed and pumped to the depropanizer in order to eliminate propane from the system. The bottoms from the depropanizer are piped to the isobutane fractionator.

The isobutane fractionator separates the iso and normal butane. Normal butane is withdrawn from the bottom and the iso-butane is taken overhead and recycled back to the mixing section as described.

Bottoms from the debutanizer tower consisting of the debutanized crude alkylate flow into the alkylate rerun column. In this column 300° F. End Point alkylate is segregated and taken overhead ready for blending with straight run gasoline and tetraethyl lead to form 100 octane aviation motor fuel. A side cut may be withdrawn from this fractionator consisting of 300° to 400° F. alkylate which may be blended into general motor fuel production. 400° F. plus alkylate may be withdrawn from the bottom of the alkylate rerun column.

The alkylation process was developed almost simultaneously by several companies which have arranged for the licensing of the process to others by the Universal Oil Products Company. Foster Wheeler Corporation offers the complete engineering, fabrication, and construction of the process.



COURTESY, FOSTER WHEELER CORPORATION

Catalytic Polymerization Process

THE U.O.P. catalytic polymerization process produces a new kind of high-octane gasoline from gases which are a by-product of cracking operations. Its utility extends over a very wide range. It is profitable for large and small refiners. The largest U.O.P. poly unit is processing 27,000,000 cubic feet of gas a day; the smallest about 125,000. This information is presented here through the co-operation of Universal Oil Products Company of Chicago.

Midget poly plants have become a factor of great importance to the smaller refiners. A number have been built in the past two years, or are now under construction, to operate in conjunction with Dubbs cracking units. They are built at low cost and their earnings pay them out very quickly. A poly unit in a small refinery was built at a cost of less than $10,000 and paid for itself in the first 30 days of operation.

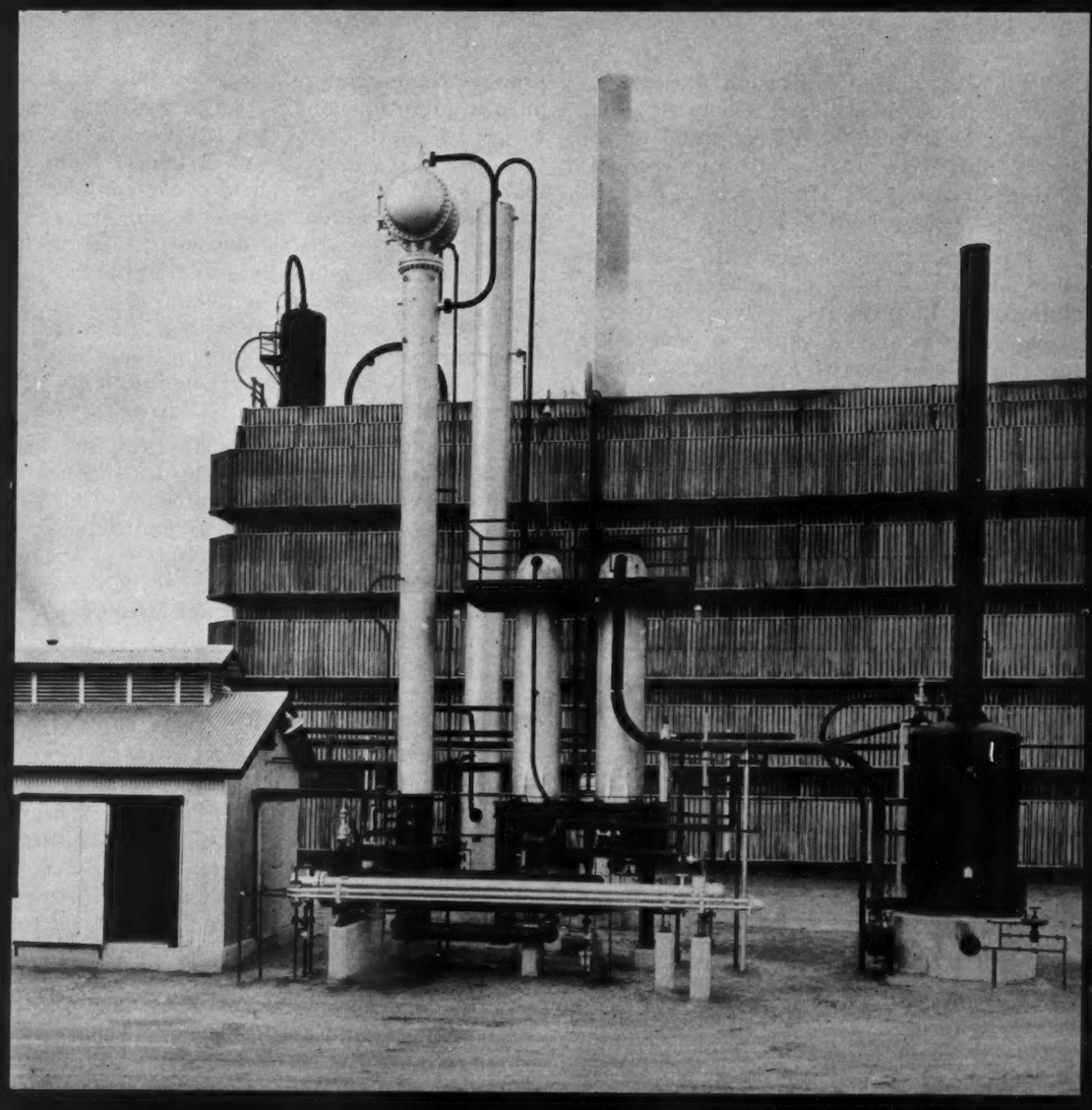
The U.O.P. catalytic polymerization process can do four important things for the refiner: (1) Increase gasoline production by 2 to 5 percent without increased crude supply. (2) By blending his output of polymer gasoline with part of his Dubbs cracked gasoline, he can produce a fuel of premium octane rating, which has a high merchandising and advertising as well as service value. (3) By blending his polymer gasoline with all his Dubbs cracked gasoline, the endpoint of his gasoline can be raised 15° to 25° F., without decreasing the overall octane number. This means increasing his gasoline yield by about 2 percent and increasing the capacity of his Dubbs units by 10 to 15 percent. (4) If "Q" gasoline is sold the refiner can cut his lead bill by reason of the high blending value of his polymer gasoline.

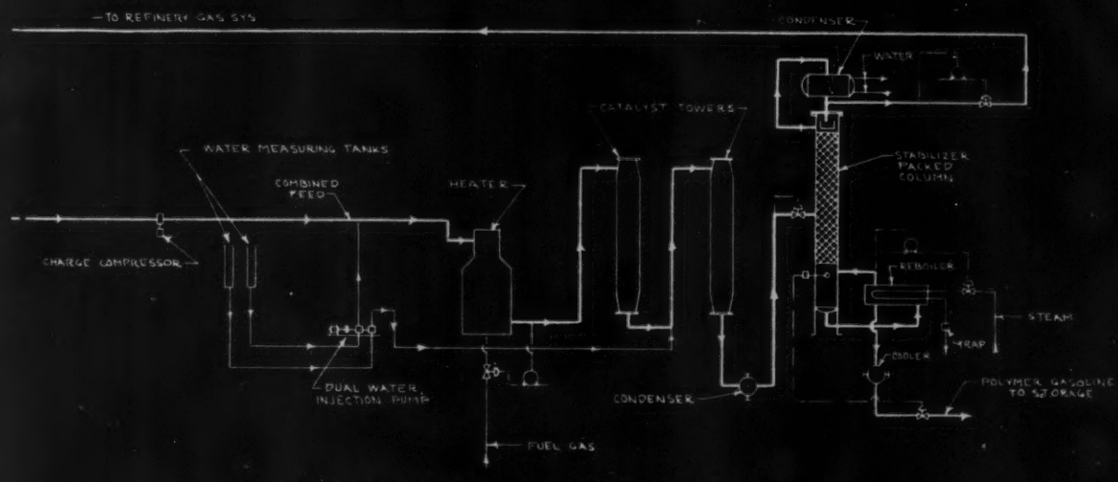
The yield of polymer gasoline depends on the percentage of heavy olefinic gases, such as propene and butenes, in the cracked gas processed. As an example, the average yield of this type of gasoline when processing Dubbs cracked stabilized gas is from five to six gallons per 1000 cubic feet. However, where the olefinic content of the gas treated is higher, proportionately higher yields of polymer products are obtained.

Since polymerization is the combination of olefins to form larger molecules it is apparent that saturated substances (paraffins) do not yield polymers. On the other hand, saturated hydrocarbons may be catalytically dehydrogenated or cracked to olefins. Thus, in order to produce gasoline from normally gaseous olefins, one reaction takes place—polymerization. In order to produce gasoline from normally gaseous paraffins, two reactions take place—one a cracking or dehydrogenation, the other polymerization. It should be pointed out that to produce olefins from paraffins, high temperature must be used, while polymerization of olefins is favored by low temperatures. To crack paraffin gases and polymerize the olefins formed calls for opposing reactions, and therefore the conditions best suited for olefin formation are not suitable for the polymerization reaction. From a theoretical and practical standpoint it is best to produce the olefin gases under optimum cracking or dehydrogenating conditions and then convert the olefins to liquids under the conditions most suitable for their polymerization. The catalyst employed in the U.O.P. catalytic polymerization process has a long life, it is not impaired by hydrogen sulfide and can be regenerated in place by a simple air-burning operation at infrequent intervals when and if this is necessary. In the new units regeneration is unnecessary.

A further development of catalytic polymerization is the U.O.P. isooctane process which produces motor fuel of 96 octane number. This fuel is useful in increasing the power output per unit weight of motor and as a result is a valued aviation fuel.

A typical flow chart of the process is shown on the opposite page, together with a photograph of a commercial U.O.P. polymerization plant, the rated capacity of which is 500,000 cubic feet per day.





U.O.P. CATALYTIC POLYMERIZATION PROCESS

COURTESY, UNIVERSAL OIL PRODUCTS COMPANY

X-YTE Percolation Filtration Process

THE X-YTE Percolation Filtration Process as developed by Max B. Miller & Company, Inc., 501 Fifth Avenue, New York, N. Y., maintains all the merits of the standard percolation filtration process and in addition contributes features which may be traced directly to the adsorbent X-YTE.

X-YTE is a product resulting from the calcining, the activation, and sizing of a very select portion of the high alumina ore Bauxite. It is only recently that extensive tests have located a supply of select ore suitable for the production of a unique product; established in the laboratory a technique for preparing and applying the product, and have perfected the final details of the process in a commercial installation in an oil refinery.

Since the X-YTE filtration process does not deviate from the major principles of the long standing standard percolation filtration process, any existing plant may use X-YTE without change except that arrangement must be made by which temperatures from 1100° F. to 1400° F. may be developed for re-burning.

When X-YTE is used in connection with the filtering of neutrals it may be re-burned at a temperature as low as 1000° F. to 1100° F. Use with heavy residual oils, however, requires a re-burning of a higher temperature. Usually 1300° F. to 1400° F. produces a maximum efficiency. The physical and mechanical properties of this adsorbent are such that temperatures of 1400° F. do not destroy its effectiveness. Fusing of the material is impossible at normal burning temperatures and burning may be carried on in multiple hearth burners or in rotary kilns. X-YTE may be re-burned and re-used until destroyed. Reports from users indicate a dust loss of not over 1 percent per cycle with careful operation. In the manufacture of X-YTE that part of the raw material which breaks down to fines on wetting is completely washed out. This produces a smooth, firm material that will stand steaming in the filters without breakdown. Using conservative figures, it is apparent that the life of X-YTE is from 100 to 200 burns.

It has been proven that throughout its life, with proper handling X-YTE retains its decolorizing efficiency of from 80 percent to 90 percent of the original material. Snow white and other light colors in petrolatum acquired by filtration through X-YTE are odorless and tasteless, regardless of the number of times that the X-YTE has been re-burned. This is also true on filtering white oils that must be odorless and tasteless. The use of X-YTE eliminates the use of activated carbon as a finishing filtering step. Since X-YTE retains its efficiency on re-burning it is neither necessary nor desirable to segregate the material from the different burns. This is effective in greatly reducing storage and inventory of new and several times burned filtering material, and greatly simplifies the handling to and from the filters.

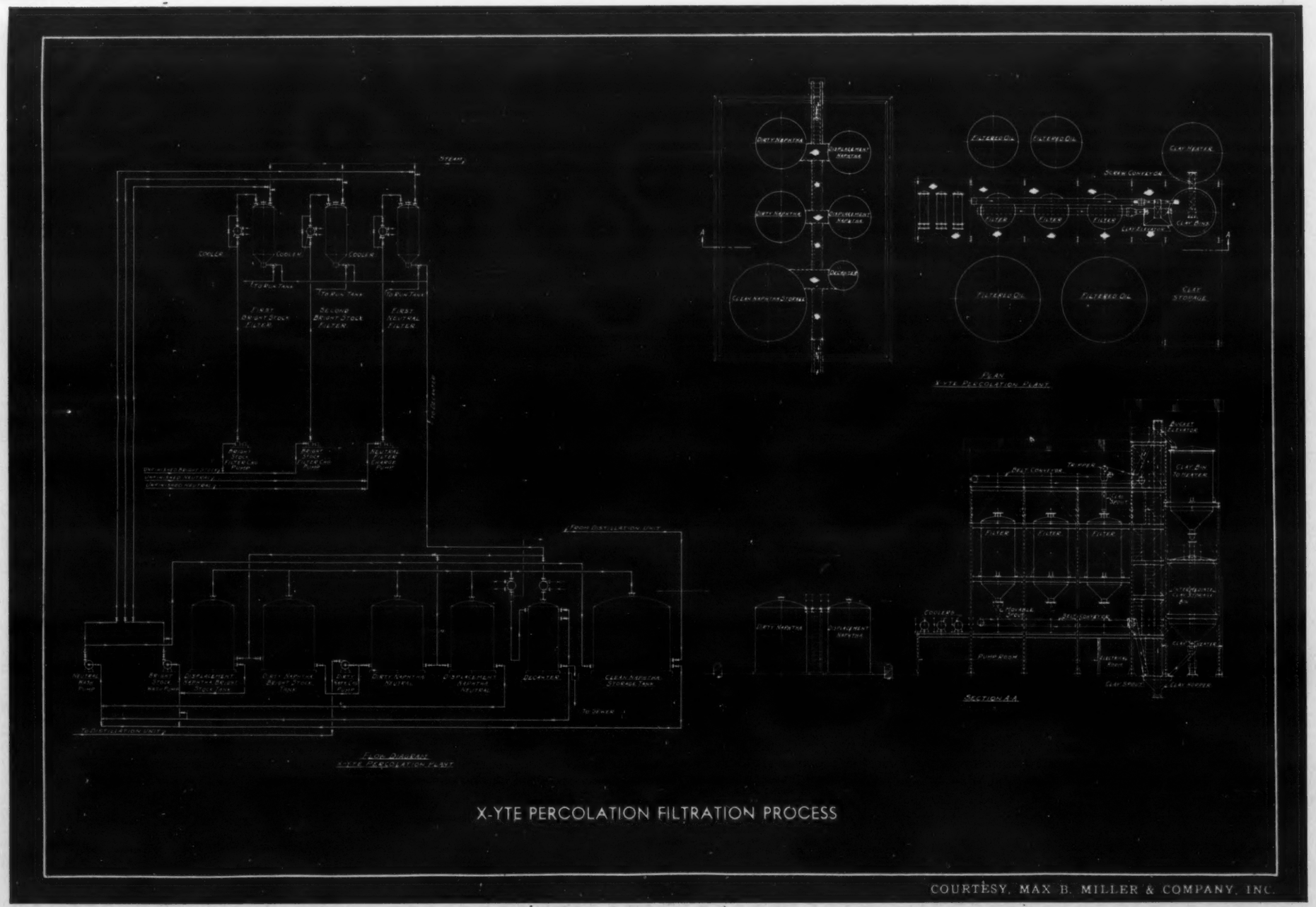
In those periods in which it has been desirable to produce the maximum amount of finished lubricating oil, the filtering plant has in many refineries proved to be the "neck of the bottle." One of the most interesting features of X-YTE comes from the fact that it will increase the yield of a given filter. Burned X-YTE is as efficient per ton as the average burned Fuller's Earth, and it is denser—weighing from 1.7 to 2.0 times as much as Fuller's Earth. In consequence, more tons can be gotten into a given filter accounting for a corresponding increase in yield. Comparative tests have shown that the yield of a given filter is 70 percent greater with X-YTE than it was in the case of Fuller's Earth.

It cannot be said, however, that the increased yield per filter derived from the use of X-YTE truly represents a net increase in the capacity of a single filter or a filter plant as a whole. A major portion of the filtering cycle is used up in charging, filter soaking time, steaming, washing, etc., and is about the same for either medium. On the total filter cycle the effective increase in filter yield with X-YTE will be less than the 70 percent mentioned. Comparative tests have again shown the advantage of X-YTE to be 40 percent increase in filter yield on the total cycle.

In the flow sheet attached three filters are provided, all the same size, having ample capacity for 15 tons of X-YTE charge. Two filters are utilized on bright stock and one on neutrals. The total filter cycle will be approximately twice as long on the neutral as for the bright stock. Provisions are made for either heating or cooling the filter charge stocks, as may be necessary, in order to maintain a constant filtering temperature. In new installations filters would be provided with a hot air jacket and the heating medium would be the hot air discharge from the cooling air for the furnace shaft and rabble arms.

After completion of the filtering cycle the stock retained in the filters is recovered by naphtha washing and steaming. Approximately half of the naphtha utilized for washing is used as a displacement wash, the other half for "mopping up." The washing cycle is so arranged that the "mopping" naphtha from the previous run is used as a displacement wash in the next run. The "dirty" wash naphtha is reduced and returned to the clean naphtha storage tank.

Provisions are made for revivifying the X-YTE by burning in a multiple hearth clay burner. Both unburned and burned clay storage are provided so that the clay burner operates continuously at the average consumption rate. A clay conveying and elevating system is provided so that any one filter may be emptied of or filled with clay in an hour. The clay burner shaft and rabble arms are provided with air cooling for protection against burning out. The warm air discharge from this cooling system is used in keeping warm the burned clay in the intermediate storage bin so that the filters can be charged with warm clay and also for keeping a constant temperature in the filters during the filtering cycle.



X-YTE PERCOLATION FILTRATION PROCESS

COURTESY, MAX B. MILLER & COMPANY, INC.

Elements of Vaporization and Condensation

PART VIII
Fractionator Design

R. L. HUNTINGTON, University of Oklahoma

FRACTIONATION is the process of separating mixtures consisting of two or more chemical compounds into their respective components and in the case of petroleum, into narrow boiling fractions. These fractions may vary in distillation ranges from 100° F. up to 400° F. for motor fuels down to substantially pure components having ranges of 2° F. or less. The separation of these various constituents from each other may be accomplished in several ways, such as crystallization, extraction, mechanical separation such as gravitation or centrifugalization, selective absorption and adsorption as well as by fractionation through a process consisting of consecutive steps of vaporization and condensation. For example, wax may be recovered from lubricating oil distillates by fractional crystallization through successive steps of chilling, pressing, and sweating. Extraction may be used effectively by reason of the preferential solubility of an unsaturated hydrocarbon in a certain solvent over that of a saturated organic compound having almost the same volatility. Amorphous wax in heavy petroleum distillates may be recovered by chilling, followed by centrifuging at high speeds. Gases may be separated in a measure by selective adsorption on activated charcoal. Although apparatus used in the above mentioned examples might be considered fractionation equipment in a broad sense, the word "fractionator" is usually thought of in connection with the separation of mixtures through vaporization and condensation steps by reason of the different vapor pressures or volatilities possessed by the components present in the mixture.

Laboratory Fractionation

Both batch and continuous methods are used in the fractionation of hydrocarbon mixtures. The batch process is employed as a rule in the laboratory, or for the manufacture of relatively small quantities of commercial products.

Laboratory columns are divided into two general types (Figure 1).

1. High temperature columns (Figure 2) for the fractionation of crude oil and its various fractions.
2. Low-temperature columns (Figure 3) for natural gas and natural gasoline.

In the operation of the high-temperature columns, the fractions boiling up to 400° to 450° F. are taken off as a rule at atmospheric pressure. The apparatus is then allowed to cool so that the heavier fractions may be distilled at reduced pressures, temperature corrections being made on vapor-pressure charts in order to estimate the boiling points at atmospheric pressure. Were vacuum not employed in such fractionations, the residuum at the base of the apparatus would crack, and thereby change the composition of the original crude oil. A sudden decrease in the overhead vapor temperature is often a good indication that cracking is taking place in the base of the column as the result of the formation of low-boiling "cracked" products.

The ordinary crude oil has such a large number of hydrocarbons contained in it, that fractionation in the usual laboratory column (5 to 6 feet in height) does not detect the presence of individual components, due to their respective boiling points being so close together. A.S.T.M. and fractional distillations on the same crude oil give curves which are

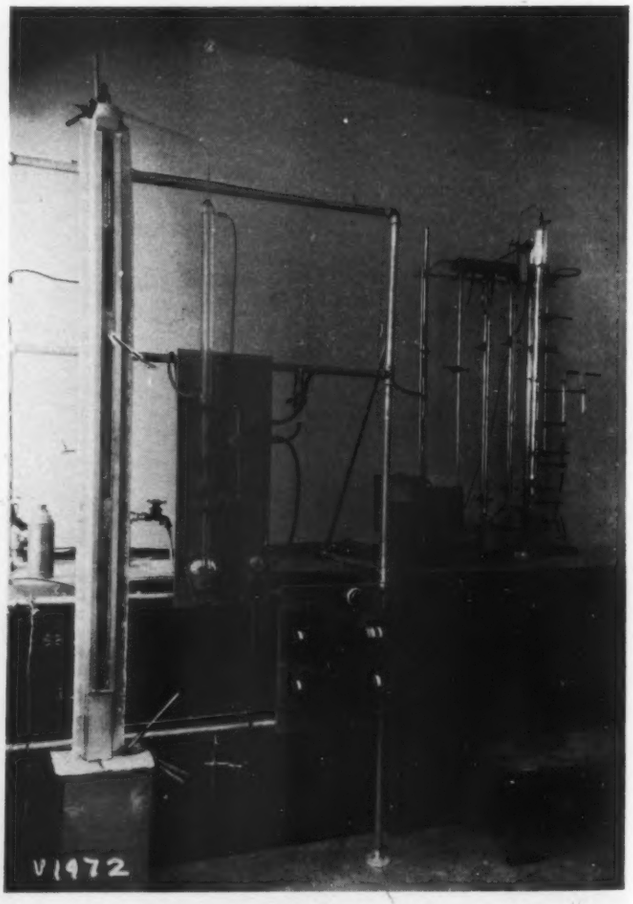


FIGURE 1

True boiling point columns. Left foreground, high-temperature column for motor fuels, crude oils and heavier fractions. On the right, Podbielniak low-temperature column.

distinctly different, as shown in Figure 4. The A.S.T.M. test (somewhat similar to the Engler) is carried out in a flask with a short unpacked vapor column in which very little, if any, fractionation takes place. As a result of this lack of separation,

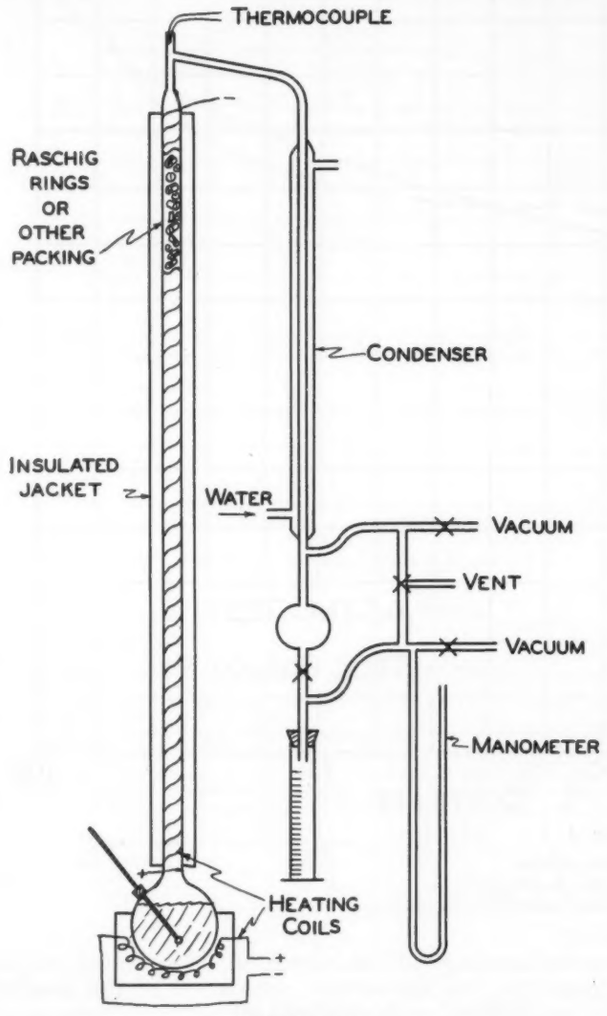


FIGURE 2
Diagrammatic sketch—High-temperature true-boiling-point column.

the A.S.T.M. test does not come so near to indicating the true initial boiling point since some heavier components come overhead with the lower-boiling ones. Likewise, a lower end point or maximum boiling temperature is obtained with the A.S.T.M.

The efficiency of any laboratory packed column is expressed in H.E.T.P. or height equivalent to a theoretical plate, i.e. the greater the efficiency the less the column height required to bring about a definite separation. The secret of a good packing material is that of securing intimate contact between the rising vapor stream and the descending liquid films. Many investigators[1, 2, 3, 4, 6] have made exhaustive studies of various types of packing, by fractionating known mixtures of hydrocarbons.

Low Temperature Fractionation in the Laboratory

The analysis of natural gas, natural gasoline, highly gas-saturated crude oil and distillates, is generally made at low pressures and temperatures in apparatus similar to that shown in Figures 1 and 3. Constituents such as water vapor, carbon dioxide, hydrogen, oxygen, hydrogen sulphide should be determined by other means such as absorption or selective combustion.

The hydrocarbon mixture is liquefied at first in the base of the column with liquid nitrogen. The spiral packing in the column is then allowed to become wet by removing refrigeration at the base and by chilling the top of the apparatus. Methane is taken off overhead as a vapor at the boiling point of that hydrocarbon, the receiving flask having first been evacuated. The increase in pressure in this flask is used as a means of measuring the volume of gas entering it. As soon as most of the methane has been fractionated out of the sample, the temperature has a tendency to rise, due to the admixture of ethane at the top of the column. The rate of product removal is then slowed down in order to secure sharper separation between the pure hydrocarbons.

Pentane and heavier fractions are taken off as vapor at sub-atmospheric pressures, otherwise condensation would occur in the vapor delivery line and the manometers. Toward the latter part of the fractionation, heat is applied to the internal electrical resistance in the distilling bulb at the base of the

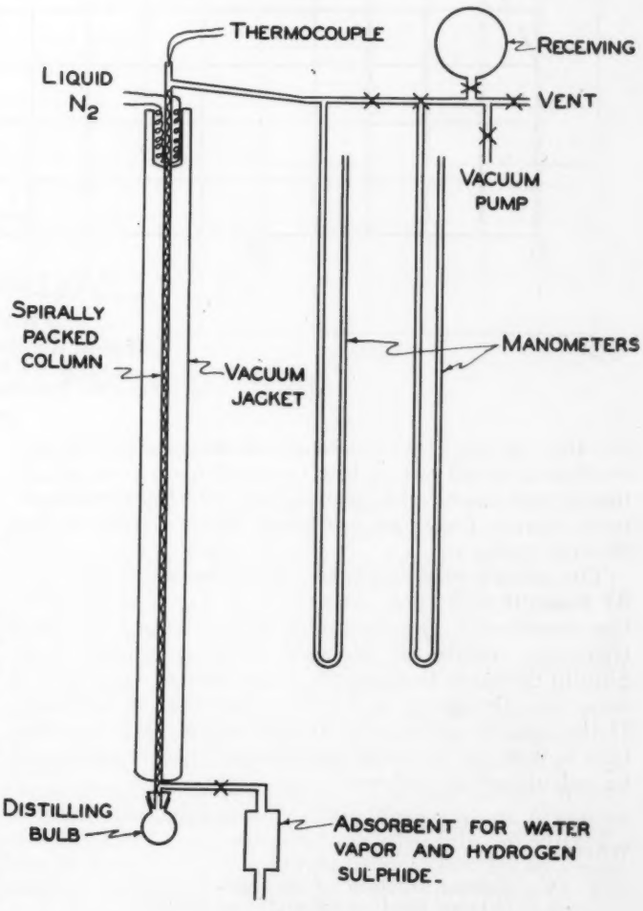


FIGURE 3
Diagrammatic sketch—Low-temperature true-boiling-point column.

column, and refrigeration is discontinued at the top. A typical low-temperature analysis is shown in Figure 5 with a graph of overhead vapor temperature versus pressure build-up in the receiving flask.

In the complete analysis of a gas-saturated crude

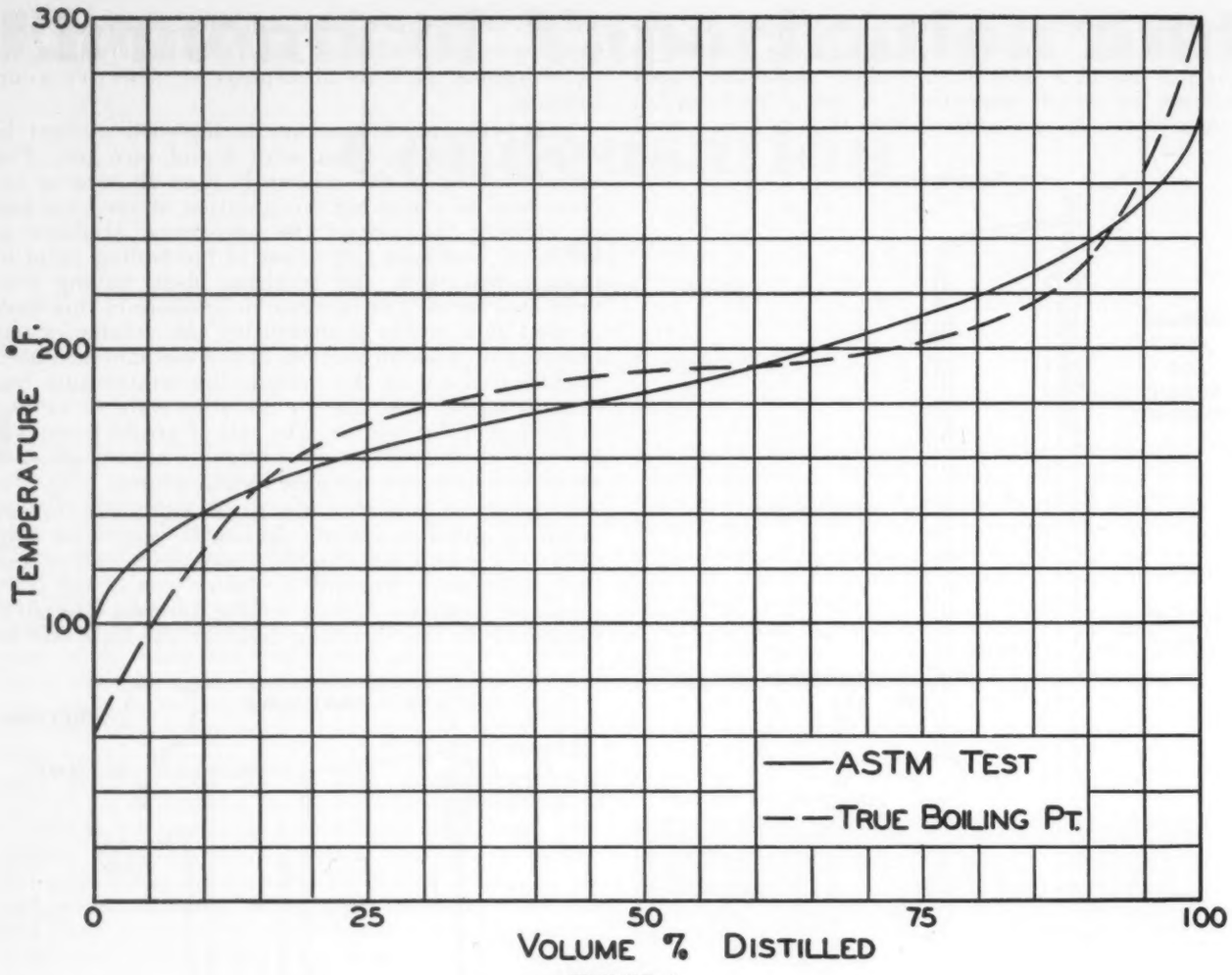


FIGURE 4
Typical distillation curves
(a) A.S.T.M. batch distillation
(b) True boiling point fractionation

oil, the lighter fractions such as hexane and lower are fractionated out at low temperatures after which the topped crude oil is transferred to a high-temperature column for more complete fractionation of the heavier ends.

The presence of nitrogen cannot be detected readily since it will come overhead as a gas along with the methane. The methane and nitrogen mixture therefore should be isolated in a weighing flask. Should nitrogen be present, its greater density would cause the sample to be heavier than that of methane. If the specific gravity of the nitrogen-methane mixture is 0.60, the volume percentage of nitrogen could be calculated as follows:

$$(x)\ .965 + (1 - x)\ .552 = 0.60$$

Where

x = volume fraction of nitrogen present
$1-x$ = volume fraction of methane present
0.965 = sp. gr. vs. air for nitrogen
0.552 = sp. gr. vs. air for methane
$x = 0.116$ (volume fraction of nitrogen present in the nitrogen-methane fraction).

Fractionation of Two Component Mixtures

In several papers[5] of this series, certain physical relationships between the variables, temperature, pressure, and composition, have been shown for binary mixtures which provide the groundwork for an understanding of fractionation. The most useful graph for the theoretical calculation of the number of equilibrium trays required for a definite separation of a binary mixture into relatively pure constituents, is the vapor-liquid equilibrium curve. This curve shows the relationship between the composition of the more volatile constituent in the vapor and the liquid ranging from 0 to 100 percent, all at one pressure. The reason for taking pressure as constant is based upon the fact that the differential in pressure throughout the height of a fractionating column is small in comparison with the temperature range from the top to the base of the tower. Fractionation could be effected through the operation of a column having a constant temperature from top to bottom were it mechanically feasible to provide appreciable pressure differentials between the successive bubble trays. Stage separation of oil-gas mixtures by several equilibrium flash vaporizations at different pressures might be considered an approach toward this type of fractionation, however, it does not provide the customary counter-current reflux flow as used in fractionators.

N Butane—Propane Mixtures

If Raoult's law is assumed to be sufficiently accurate for the estimation of the liquid-vapor equilibrium curve, the following procedure for obtaining the cor-

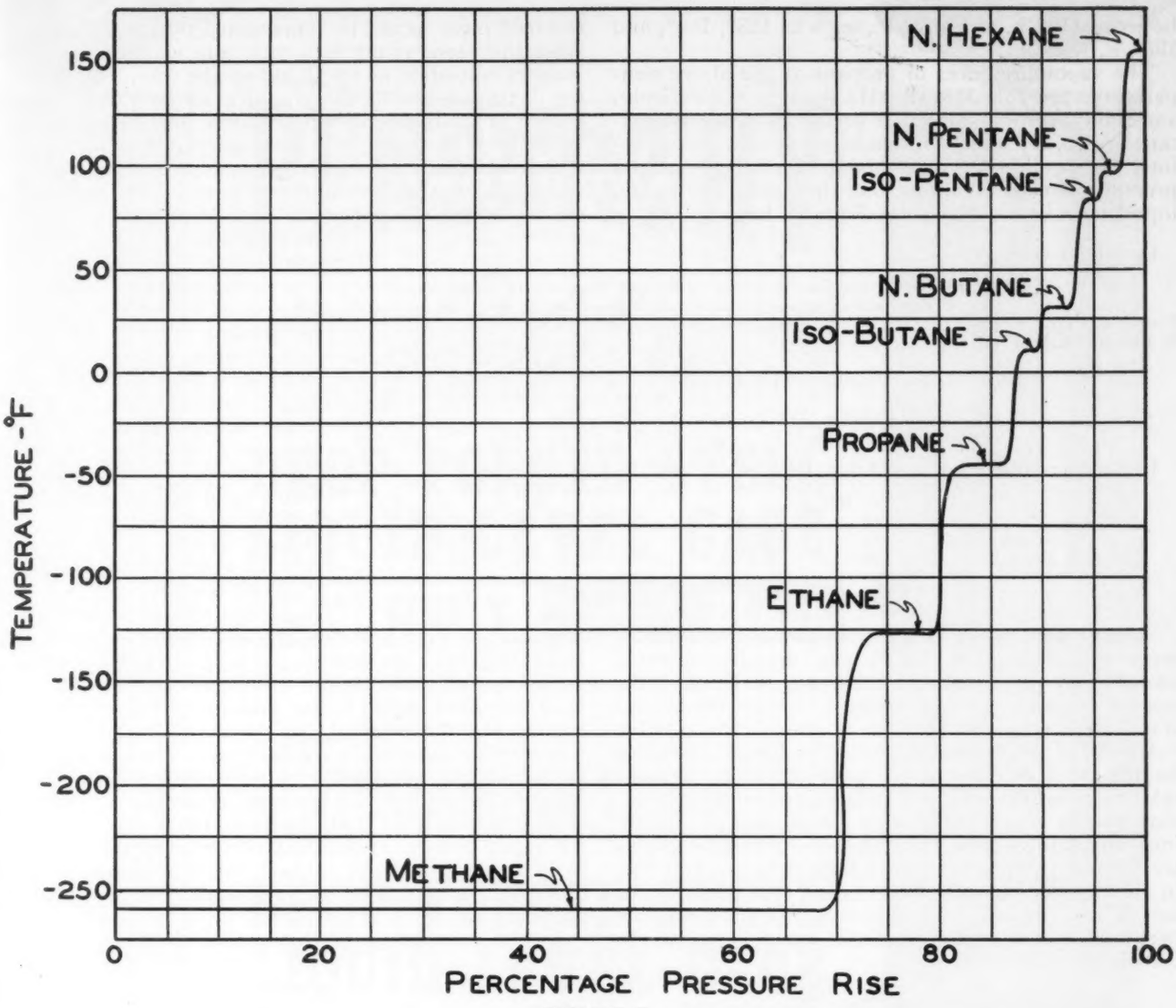


FIGURE 5

Typical analysis of natural gasoline with true boiling point apparatus

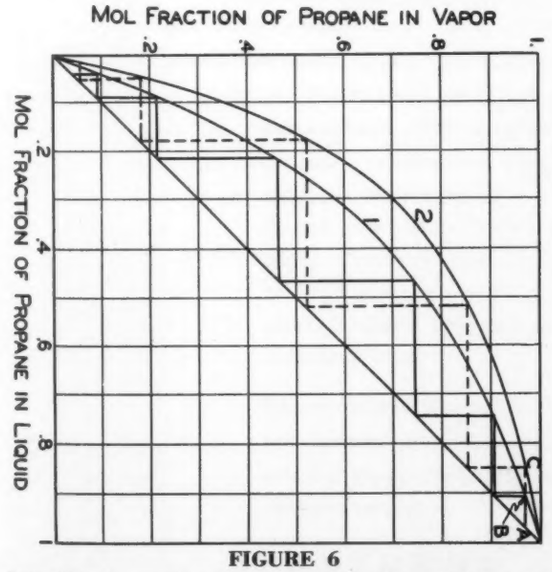


FIGURE 6

McCabe-Thiele graphical method for determination of the number of theoretical plates for fractionation of binary mixtures. Comparison of high and low pressure operations. Curve 1 = 215 lb./sq. in. abs. Curve 2 = 14.7 lb./sq. in. abs.

responding mol fractions of the more volatile constituent in the vapor and in the liquid, may be used. If the overhead vapor is to be totally condensed in coils in contact with atmospheric cooling water, it is probable that the water will run as high as 90° F. in temperature when the wet bulb is 80° F. The condensate or reflux will be about 20° F. higher than the cooling water for conventional design, or in this case 110° F. The vapor pressure of propane at 110° F. is 215 pounds per square inch absolute or approximately 200 pounds gage pressure at sea level. The other extreme of the binary mixture range would be pure normal butane which has a vapor pressure of 63 pounds per square inch absolute at 110° F., but it requires a temperature of 207° F. to cause normal butane to exert a vapor pressure of 215 pounds per square inch absolute. If it were possible to separate normal butane and propane completely in a column operating at 215 pounds per square inch absolute, the temperature would range from 110° F. at the top in the condenser to 207° F. at the base. Intermediate values for vapor and liquid compositions between 100 percent normal butane and 100 percent propane can be calculated without the trial-and-error method by selecting several temperatures

between 110° F. and 207° F., such as 125°, 160°, and 195° F.

The vapor pressures of propane at the above temperatures are 255, 375, and 475 pounds, respectively, and the corresponding vapor pressures of normal butane are 78, 124 and 187 pounds per square inch absolute. The equilibrium relationship between the partial pressure of each component in the vapor and in the liquid may be expressed by Raoult's law:

Example 1 (125° F.)

Total Pressure × mol frac in vapor = Partial Pressure in liquid phase

Partial Pressure in vapor phase = vapor pressure × mol frac in liquid

Propane (C_3H_8)	(1)	215	(y_3)	$=255$	(x_3)
N Butane (C_4H_{10})	(2)	215	(y_4)	$= 78$	(x_4)
	(3)	215	$(1-y_3)$	$= 78$	$(1-x_3)$

(4) Adding equations (1) and (3)

$215 = 78 + 177\ x_3$

(5) $x_3 = 137/177 = .774$ $\quad x_4 = 1 - .774 = .226$

(6) From equation (1) $\quad y_3 = 255/215\ (.774) = .916$ $\quad y_4 = .084$

In a similar manner it is found that the values for 160° F. and 195° F. are:

	160° F.		195° F.	
	(x)	(y)	(x)	(y)
Propane	.354	.618	.097	.214
N Butane	.646	.382	.903	.786
	1.000	1.000	1.000	1.000

A large percentage of the stabilizer columns which were installed in the 1920-1930 decade, operated under lower pressures and temperatures, through the use of propane as a refrigerant. Fewer theoretical trays were required because of the higher relative volatility of the hydrocarbons under lower pressures. In Fig. 6 it is easy to see how much greater the relative volatility (Curve 2) is at atmospheric pressure than it is at a pressure of 215 pounds per square inch absolute (Curve 1). These low-pressure towers were rapidly replaced by the high-pressure columns in view of the cheaper refrigeration cost through the use of atmospheric cooling water. Furthermore, the permissible mass velocity of the vapor is greater in the higher-pressure towers.

Minimum Theoretical Tray Requirement

If a 50-50 molal mixture of propane and normal butane is to be fractionated in such a manner that the overhead product will be 97 mol percent propane, and the bottoms 3 percent propane, the number of theoretical trays can be calculated algebraically (Sorel method)[7] or graphically by the McCabe-Thiele method.[6] For a minimum number of trays, infinite reflux would be required, i.e., substantially no product would be removed overhead or at the base. The operating or material balance line both above and below the feed plate would be represented by the 45° slope since the vapor rising into each tray would have the same composition as the liquid on the tray. The number of trays found by the graphical method have been drawn in for both the high and low pressure towers. Point (A) represents the total overhead condensate which has the same composition as the vapor rising from the top tray in the fractionator. The liquid on the top tray has a composition of 91 percent propane corresponding to (B) on the equilibrium Curve 1 and to (c) or 85 percent propane for Curve 2, both obtained by reading valves directly below these points on the abscissa. The next step is to drop a line down to the 45° slope, or operating line to find the composition of the vapor rising into the tray, which is, of course, the same as the liquid on the tray for infinite reflux. Continuing this procedure it is found that the low-pressure tower requires 4.5 theoretical trays whereas the high-pressure column needs 6.0 trays.

The algebraic method would give the same results as the graphical solution, however, the amount of work required would be far greater for the algebraic attack. For the first calculation of the liquid on the top tray, it would be necessary to assume temperatures by trial and error until an equilibrium balance was obtained such that the sum of the mol fractions would be equal to unity both in the liquid and in the vapor phases. This calculation would be followed by a material balance around the tray in order to obtain the composition of the vapor rising into the plate.

In the next paper of this series, the author will take up other cases of the fractionation of binary mixtures in which finite reflux ratios will be considered.

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[4] Garton, V. W., et al, Refiner and Natural Gasoline Manufacturer, 14, 60, 1935.

[5] Huntington, R. L., Refiner and Natural Gasoline Manufacturer, January-August, inclusive, 1940.

[6] McCabe and Thiele, Industrial and Engineering Chemistry, 17, 605, 1925.

[7] Sorel, "La rectification de l'alcool," Paris, 1893.

PENBERTHY PRODUCTS

Reflex

DROP FORGED STEEL LIQUID LEVEL GAGE

EMPTY SPACE SHOWS **WHITE** | LIQUID SHOWS **BLACK**

* * *

Transparent

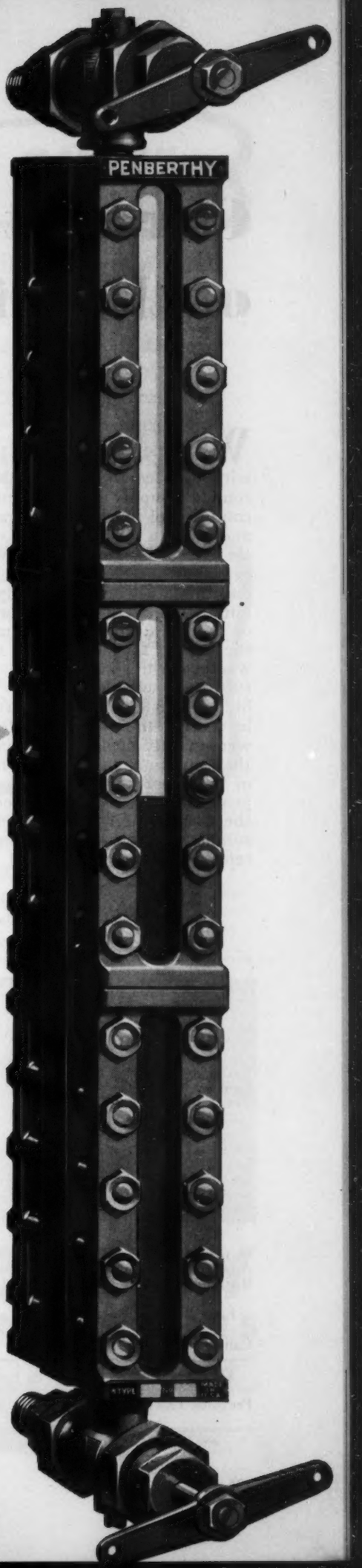
DROP FORGED STEEL LIQUID LEVEL GAGE

USED TO OBSERVE COLOR AND DENSITY OF LIQUIDS UNDER HIGH PRESSURES, AND/OR TEMPERATURES

These gages are made of alloy temperature resisting steel and are of the highest quality throughout. Liquid chamber (both single and multiple section) is made from a solid block of steel to assure perfect alignment and rigidity. Frame has extra heavy beam at each end and glass chamber is accurately machined to contour of glass providing full metal backing for gaskets. Gage valves are drop forged steel with stainless trim.

These gages are available in any length and for various pressures and temperatures. All Penberthy gages conform with A. P. I.—A. S. M. E. requirements.

PENBERTHY INJECTOR CO.
DETROIT, MICHIGAN
Canadian Plant: WINDSOR, ONTARIO



STATEMENT TO INTERSTATE OIL COMPACT COMMISSION, AUGUST 23, 1940

Current Statistical Position of the Oil Industry

FRED VAN COVERN
Director, Department of Statistics, American Petroleum Institute

IN contemplating the outline of this paper, I thought it desirable to depart from its specific title to some extent, at least, and to prepare my remarks in the form of three general classifications as follows:

1. **A review of the situation as it existed at the beginning of the 1940 summer season, or, on March 31;**
2. **The developments so far during the summer and the probable general position as of the end of September; and**
3. **An attempt to look ahead through the last quarter of 1940, and the first quarter of 1941.**

WE are, of course, all familiar with the conditions which surrounded supply and demand and condition of inventories of gasoline and furnace oils as they existed at the end of last winter. All will recall that on September 30, 1939, gasoline stocks were already high but that furnace oil inventories as of that date proved inadequate in the face of the very severe winter weather which followed. As a result, gasoline inventories on March 31, 1940, established a record-high level and stocks of distillate fuels were greatly depleted. In review of that situation, comparative figures of the inventories of those two products, as the industry entered the past winter and the current summer season, are indicated, by refinery districts, in Table 1.

Other important items that were in mind at that time were the trend of the export market and the sustained downward trend of our own domestic business activity. It was, nevertheless, a fact that during the first quarter of this year the demand for the industry's principal product increased domestically about 5½ percent. With the exports of gasoline falling off very nearly half, the total demand for motor fuel was, however, only 1.4 percent greater than during the first quarter of 1939. The combined domestic and export demand for distillate fuels and heavy fuel oils indicated increases of slightly less than 18 percent and 5 percent respectively during this three-months period.

TABLE 1
(Barrels of 42 Gallons)
(All figures are from U. S. Bureau of Mines)

DISTRICT	Finished and Unfinished Gasoline Inventories		Gas Oil and Distillate Fuel Oil Inventories	
	Sept. 30, 1939	March 31, 1940	Sept. 30, 1939	March 31, 1940
East Coast	18,653,000	22,472,000	13,094,000	5,683,000
Louisiana Gulf	1,988,000	3,007,000	852,000	631,000
Texas Gulf	11,439,000	19,383,000	6,455,000	3,306,000
	32,080,000	44,862,000	20,401,000	9,620,000
Ind., Ill., Ky.	11,778,000	19,979,000	4,810,000	2,452,000
Okla., Kansas	6,007,000	8,983,000	1,821,000	881,000
Inland Texas	1,919,000	2,851,000	363,000	128,000
No. La.-Ark.	488,000	947,000	218,000	125,000
	20,192,000	32,760,000	7,212,000	3,586,000
Appalachian	2,715,000	4,502,000	318,000	312,000
Rocky Mountain	1,376,000	2,514,000	227,000	266,000
East of California	56,363,000	84,638,000	28,158,000	13,784,000
California	14,629,000	19,072,000	9,980,000	9,302,000
Total United States	70,992,000	103,710,000	38,138,000	23,086,000
Prevoius Year	69,086,000	87,121,000	*	25,899,000

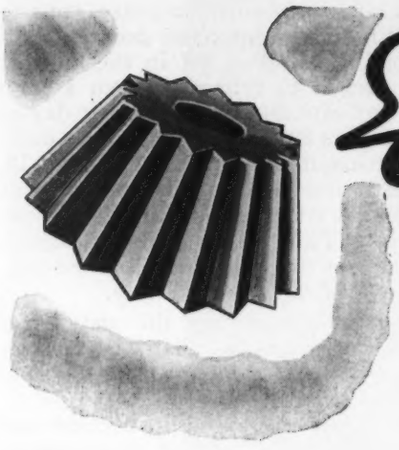
* Not available for 1938 on a completely comparable basis.

Crude oil inventories and runs to stills were showing sustained trends upward and probably were directly related to the increasing level of crude oil production. Distillate-fuel-oil burners were continuing to be installed at a rapid rate and automobile sales were going ahead very fast. Taken all in all the industry seemed to have a job on its hands in properly balancing the various pluses and minuses in the then-existing situation.

Upturn in May

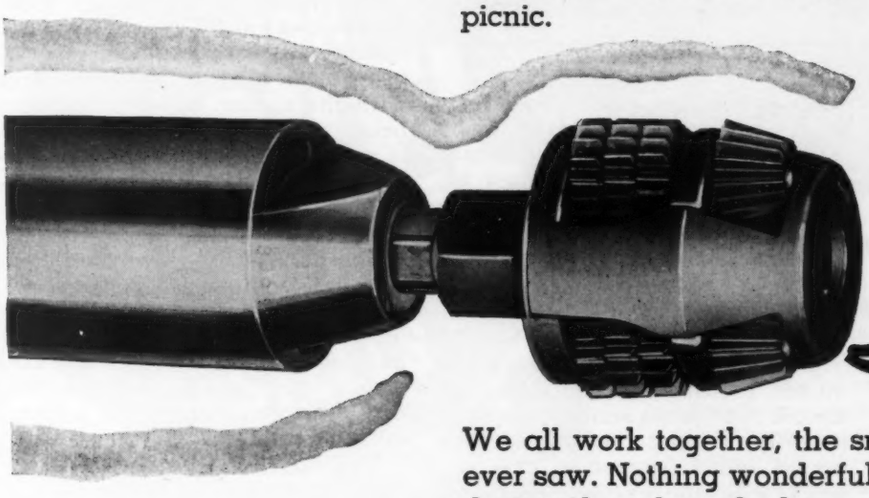
The rapid decline in business activity of the first quarter tapered off in April, the Federal Reserve Board Index reaching a low of 102 during that month. The trend turned upward, however, in May, increasing each month since then and to such an extent that our latest estimates show a level of 115 for the week ended August 10.

Sales of motor vehicles, which were high during even the first



"I'M A HARD GUY!"

The toughening process I've been through would make a defeated heavy-weight seem like a pampered kitten, but it's given me what I need in my business — hard tough edges that can gouge and tear and bite through the meanest coke that ever fouled a tube. My job is on the business end of a Lagonda-Liberty tube cleaner, along with a bunch of others like me, in a head that backs us up, and a motor that drives us through the opposition like shock troops through a Sunday School picnic.

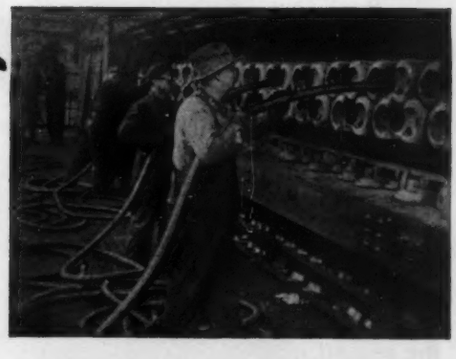


"THIS IS ME WITH THE GANG"

We all work together, the smoothest, fastest team you ever saw. Nothing wonderful about that, because we're designed and made by an organization that's been developing, testing and improving tools like us since before the oil industry started.

"WE'RE IN THERE, WORKING"

— and are those tubes going to be clean when we get through! Clean and unscarred, because while we're tough on coke, we're tender to tube surfaces. Most refinery people are pretty interested in the way we work. **There's a booklet about us, and you can get it by asking for "Tube Cleaners for Oil Refineries." You'll find it good reading.**



LAGONDA - LIBERTY

TUBE CLEANERS FOR OIL REFINERIES

ELLIOTT COMPANY

LAGONDA-LIBERTY Tube Cleaner Dept., SPRINGFIELD, OHIO

Y-156

TABLE 2

Crude Oil Production—Daily Averages

(Barrels of 42 Gallons)

DISTRICT	WEEKS ENDED July 6, 1940 A.P.I.	July 13, 1940 A.P.I.	July 20, 1940 A.P.I.	July 27, 1940 A.P.I.	Aug. 3, 1940 A.P.I.	Aug. 10, 1940 A.P.I.
Oklahoma	427,900	409,800	417,250	405,800	410,000	381,800
Kansas	182,450	178,200	189,950	186,200	183,150	169,150
Texas	1,138,350	1,143,350	1,168,050	1,354,200	1,169,900	1,176,000
California	625,700	625,100	617,600	606,000	601,600	631,800
Illinois	503,650	485,850	460,500	418,450	406,650	395,050
Arkansas	71,300	72,400	72,450	72,600	72,400	73,050
Louisiana	287,950	281,950	285,950	279,750	280,100	281,400
New Mexico	105,050	105,050	104,350	105,100	105,050	101,600
Michigan	55,900	54,150	54,100	53,600	54,750	54,150
Others	204,150	204,900	210,150	208,700	209,950	211,300
Total U. S.	3,602,400	3,560,750	3,580,350	3,690,400	3,493,550	3,475,300
Total East of Calif.	2,976,700	2,935,650	2,962,750	3,084,400	2,891,950	2,843,500

quarter, continued at a level 26 percent greater than in the previous year, during the second quarter, resulting in a 27 percent increase in motor vehicle sales during the first half of this year, and contributing to an increase of more than 4 percent in the total number of vehicles in use during the first six months.

Coincident with this first-half trend of motor vehicle sales and registrations, domestic demand for motor fuel increased slightly over 7 percent. Exports, reflecting events abroad, continued downward with the exception of June, showing a 47 percent decline when compared with the first half of 1939. As a result, total demand upon American refiners for their principal product increased but 3.0 percent during this six-months period. Crude oil production and runs to stills continued at economically unjustifiably high levels, however, and increased to such an extent that a record daily rate of refinery runs of almost 3,700,000 barrels per day was established during the week ended June 22, and an average of just over 3,600,000 barrels daily for the month.

As a result, motor-fuel inventories were drawn on only to the extent of 10,000,000 barrels during the second quarter, leaving a June 30 total of finished and unfinished gasoline at 93,600,000 barrels in comparison with 103,700,000 barrels on March 31.

Crude-oil production which saw a high of 3,800,000 barrels daily in March, and only slightly less in April, turned down to some extent in May and June and has been establishing an almost unbroken series of lower levels since July 6, when production was approximately 3,600,000 barrels daily. The latest figures available as this was written were those of August 10, during which week crude-oil production averaged 3,475,000 barrels per day. This trend is indicated in Table 2.

Still Runs Decline

The daily average rate of crude oil run to stills has also shown an almost continuous series of declines recently. During the seven-weeks period ended August 10 in every week with the exception of one, that of July 27 in which there was a relatively small increase, runs to stills have registered declines indicating a falling off in the amount charged to refineries from a high level of 3,690,000 barrels per day as of June 22 to 3,435,000 barrels daily during the week ended August 10, a decline in the daily rate of runs of 255,000 barrels during this period. This undoubtedly is significant of the understanding and attitude of refiners generally.

Table 3 shows the details of these figures, by districts and important groupings, during the period referred to.

While crude-oil production and runs to stills worked up in almost continuous trends, remaining high through the entire first half of the year, crude oil inventories were also increasing. True, the recent rate of increase in crude stocks has slowed up some in comparison with the earlier months, probably being affected by the recent trend of production, but these inventories are, nevertheless, still going up as Table 4 will show.

The trend of gasoline inventories which accelerated downward during June, influenced to some extent, no doubt, by forward buying in anticipation of the then proposed increase in the federal gasoline tax, which later became an actuality, slowed up some in July as a direct reflection.

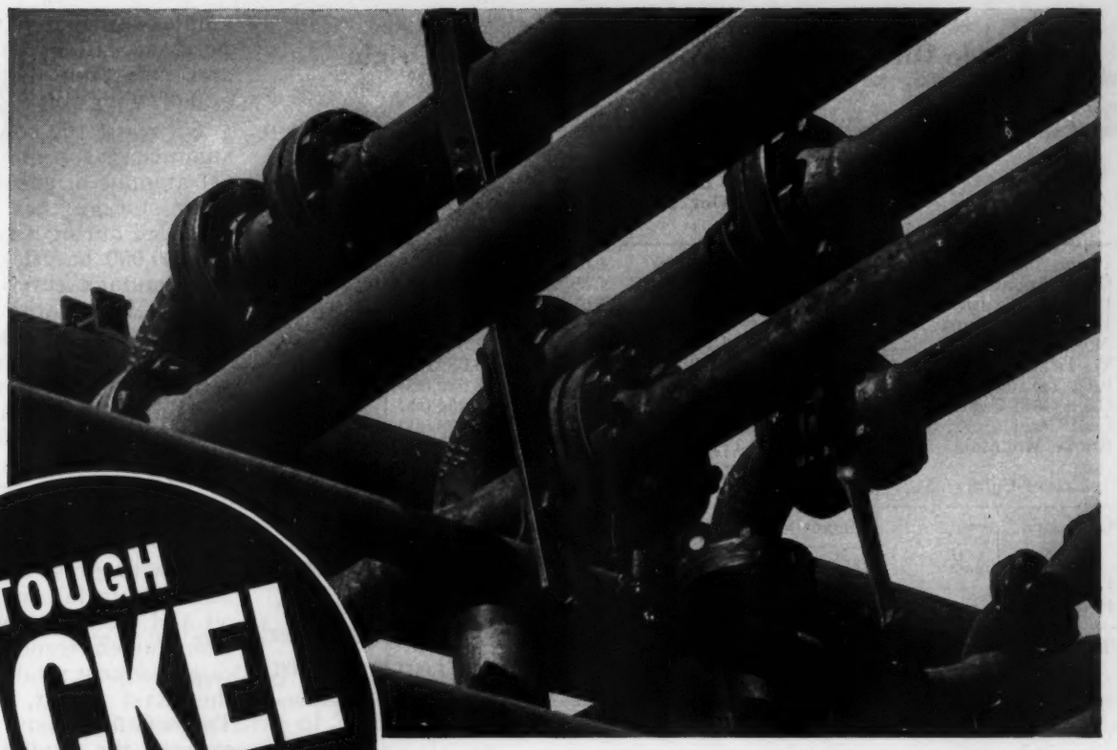
The latest figures available are those of August 10. They show a total inventory of finished and un-

TABLE 3

Crude Oil Runs to Stills—Daily Averages

(Barrels of 42 Gallons)

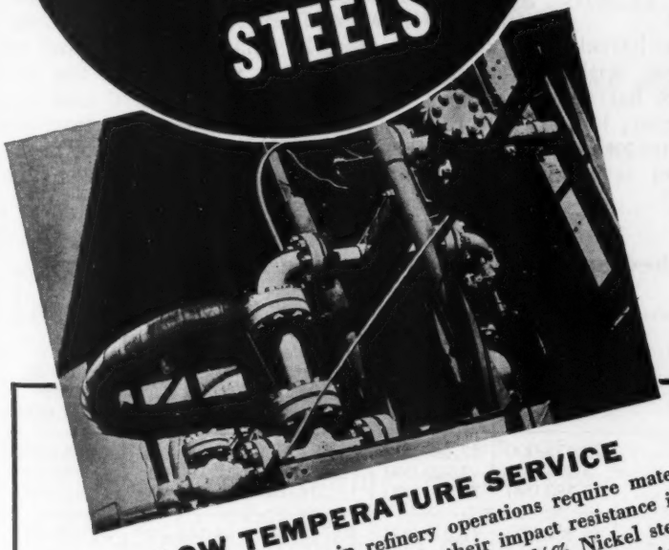
DISTRICT	WEEKS ENDED June 22, 1940 A.P.I.	July 6, 1940 A.P.I.	July 20, 1940 A.P.I.	Aug. 3, 1940 A.P.I.	Aug. 10, 1940 A.P.I.
East Coast	603,000	529,000	547,000	549,000	558,000
Louisiana Gulf	120,000	139,000	116,000	121,000	126,000
Texas Gulf	932,000	934,000	917,000	915,000	846,000
	1,655,000	1,602,000	1,580,000	1,585,000	1,530,000
Ind., Ill., Ky.	654,000	673,000	655,000	616,000	592,000
Okla., Kans.	331,000	315,000	321,000	309,000	314,000
Inland Texas	173,000	161,000	171,000	161,000	177,000
No. La. and Ark.	66,000	72,000	67,000	70,000	77,000
	1,224,000	1,221,000	1,214,000	1,156,000	1,160,000
Appalachian	128,000	123,000	131,000	127,000	125,000
Rocky Mountain	79,000	79,000	77,000	88,000	104,000
East of California	3,086,000	3,025,000	3,002,000	2,956,000	2,919,000
California	604,000	550,000	538,000	554,000	516,000
Total United States	3,690,000	3,575,000	3,540,000	3,510,000	3,435,000



TOUGH NICKEL ALLOY STEELS

HIGH TEMPERATURE SERVICE

When refinery lines are running at high temperatures, leakage or failure of a pipe joint may be the forerunner of disaster —loss of property and even life. Hence, refinery bolts must be made of sure, dependable materials—capable of withstanding severe mechanical stresses as well as the thermal and pressure extremes encountered when the lines are running hot in operation. Strong, tough, stress-resisting Nickel alloy steels SAE 4340 and SAE 3140 are widely used for this vital application as evidenced by these two scenes in a large Mid-Continent refinery where bolts of the latter Nickel alloy steel, manufactured by the St. Louis Screw & Bolt Co., are rendering long, safe service, minimizing the danger of leakage and failure.



LOW TEMPERATURE SERVICE

Sub-zero temperatures in refinery operations require materials which stay tough and retain their impact resistance in extremely cold zones. Bolts of SAE 2315 3½% Nickel steel resist low temperature embrittlement and provide requisite physical properties. Tough, dependable, long-lasting Nickel alloy steels are also widely used for other refinery applications including exchangers, condensers, coolers, valve bodies, pressure vessels, return bends, tube supports and dewaxers.

BOLTS THAT STAY TOUGH AT HIGH AND LOW TEMPERATURES

CONSULTATION is invited regarding Nickel alloy steels which assure a safe margin of strength and toughness at both elevated and sub-zero temperatures.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

TABLE 4

Crude Oil Inventories by Field or State of Origin

(Barrels of 42 Gallons)
(U. S. Bureau of Mines)

	1939 High April 30	*1939 Low Oct. 31	1940 Low Jan. 1	June 30, 1940	Last Available Aug. 10, 1940
Penna. Grade	5,647,000	4,972,000	4,624,000	4,480,000	4,666,000
Other Appalachian	1,278,000	1,547,000	1,365,000	1,331,000	1,439,000
Lima, N. E. Ind. Mich.	1,988,000	2,036,000	1,612,000	1,461,000	1,458,000
Ill., S. W. Indiana	13,183,000	17,041,000	16,932,000	21,666,000	21,607,000
No. La.-Ark.	9,205,000	6,113,000	6,401,000	7,848,000	7,991,000
W. Texas-S. E. N. Mex.	22,541,000	20,249,000	21,403,000	26,089,000	25,244,000
East Texas	22,660,000	13,613,000	15,558,000	18,689,000	19,707,000
Other Mid-Continent	108,311,000	86,330,000	89,326,000	97,454,000	98,268,000
Gulf Coast	30,091,000	23,532,000	25,605,000	28,398,000	27,520,000
Rocky Mountain	20,490,000	17,835,000	17,891,000	16,135,000	16,114,000
East of California	235,394,000	193,268,000	200,617,000	223,551,000	224,014,000
California	39,699,000	35,533,000	35,478,000	35,368,000	36,344,000
Total—Domestic	275,093,000	228,801,000	236,095,000	258,919,000	260,358,000
Foreign—(East of Cal.)	3,472,000	2,053,000	2,815,000	3,052,000	3,249,000
Total Domestic and Foreign	278,565,000	230,854,000	238,910,000	261,971,000	263,607,000

* Lowest since January 31, 1922. Lease stocks are included above.

finished gasoline of 88,100,000 barrels, a decline of about 15½ million since March 31, but still 12 million barrels greater than on the corresponding date in 1939.

This 12 million barrels difference is in direct comparison with the 16½ million barrel greater inventories on March 31 of this year. In other words, while the industry entered the current season with inventories 16½ million barrels greater than a year ago, the difference which existed on August 10 was 12 million, a 4½ million barrel relative improvement.

Finished and unfinished gasoline inventories are shown by districts as of comparable dates in Table 5.

It is, of course, both timely and very interesting to look ahead in an attempt to forecast what the level of these inventories may be on September 30 and what these relationships may show in comparison with last year. Doing this involves many uncertainties, however. Is crude oil production going to remain at or near present levels? Are runs to stills going to continue at approximately the current rate? If they do, and if present expected demand materializes—and the latter probably is the least uncertain—these inventories may total 78 million barrels. I shall not attempt to break this figure up into the various Bureau of Mines' refinery districts, but making a separation as between California and the area East of California, the figures appear at this time to be about as follows:

September 30	East of California	California	United States
1940	62,000,000	16,000,000	78,000,000
1939	56,363,000	14,629,000	70,992,000

The 78-million-barrel figure compares, of course, with last summer's 71 million barrels. I believe it would, however, be difficult to deny the statement that last year's 71 million level was more than ample, and that it was more than necessary to operate distributing and marketing facilities properly and economically.

So, while the completion of this summer season may see the greatest amount of gasoline withdrawn from storage that has ever been recorded during any similar period (25,700,000 barrels) the industry's disadvantage entering the coming winter in relation to economic minimum operating requirements will be greater than a year ago. It is important, I think, however, to state right here that the current light fuel oil situation has a very direct bearing on, and relationship to, what has just been said.

Expected Fuel Demand Increase

That progress has been made in building up fall inventories of gas oil and distillate fuels is apparent from current trends. Of course, the districts most vitally concerned are the East Coast, Louisiana and Texas Gulf Coasts, and to a lesser extent, the Indiana-Illinois and Oklahoma-Kansas regions. There will probably be 2,150,000 home-heating oil burners in use on an average during next winter, an increase of 13 percent over the average in use during the previous winter. In relation to the kind of weather that will prevail, the domestic demand for gas oil and distillate fuel, of which heating oil comprises the major portion, probably will increase from 12 to 17

TABLE 5

Finished and Unfinished Gasoline Inventories

(Barrels of 42 Gallons)

DISTRICT	March 31, 1940 U.S.B.of M.	July 31, 1940 Estimated	August 10, 1940 Estimated	August 10, 1939 *U.S.B. of M.	Sept. 30, 1939 U.S.B.of M.
East Coast	22,472,000	22,426,000	21,683,000	20,882,000	18,653,000
Louisiana Gulf	3,007,000	2,725,000	2,780,000	2,182,000	1,988,000
Texas Gulf	19,383,000	16,367,000	16,334,000	11,084,000	11,439,000
	44,862,000	41,518,000	40,797,000	34,148,000	32,080,000
Ind., Ill., Ky.	19,979,000	16,283,000	15,805,000	12,820,000	11,778,000
Okla., Kans., Mo.	8,983,000	6,699,000	6,562,000	6,581,000	6,007,000
Inland Texas	2,851,000	2,536,000	2,538,000	2,042,000	1,919,000
No. La.-Ark.	947,000	757,000	716,000	615,000	488,000
	32,760,000	26,275,000	25,621,000	22,058,000	20,192,000
Appalachian	4,502,000	3,716,000	3,757,000	3,551,000	2,715,000
Rocky Mountain	2,514,000	1,654,000	1,610,000	1,533,000	1,376,000
East of California	84,638,000	73,163,000	71,785,000	61,290,000	56,363,000
California	19,072,000	16,621,000	16,330,000	14,776,000	14,629,000
Total United States	103,710,000	89,784,000	88,115,000	76,066,000	70,992,000

* Estimated from Bureau of Mines July 31 and August 31 figures so as to make possible a comparison with latest available 1940 figures.

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— a spread between the CFR-ASTM and research octane of from 9 to 14 numbers—and between CFR-ASTM and road octane of 3 to 8 numbers, depending on feed stock and operation.

— high blending value and good lead susceptibility.

— high overall yields.

— aviation gasoline base stock.

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TABLE 6

Refinery and Bulk Terminal Inventories of Gas and Distillate Fuel Oils and Yields of Light Fuels and Gasoline in Certain Geographical Areas—1939 and 1940

	Jan. 1	Jan. 31	Feb. 28-29	March 31	April 30	May 31	June 30	July 31	August 31	Sept. 30	Estimated Economic Requirements, Sept. 30, 1940
EAST COAST & GULF COASTS:											
Inventories (barrels)...1939	19,849,000	16,605,000	14,034,000	12,025,000	11,732,000	12,963,000	15,784,000	18,425,000	19,966,000	20,401,000	.....
Inventories (barrels)...1940	16,924,000	12,210,000	11,257,000	9,620,000	11,158,000	13,516,000	17,640,000	*22,300,000	.....	.....	28,000,000
Yield Gas & Distillate Fuel (Percent).....1939	.....	17.4	18.4	16.8	15.7	14.5	16.5	14.7	14.9	15.2	.....
Yield Gas & Distillate Fuel (Percent).....1940	.....	19.5	22.2	18.9	18.7	16.7	17.1	.....	.....	.....	.....
Yield Gaso. (Percent)..1939	.....	42.0	41.1	41.3	42.3	42.1	41.6	41.6	42.7	42.2	.....
Yield Gaso. (Percent)..1940	.....	38.5	39.1	38.5	40.1	37.4	39.2	.....	.....	.....	.....
INDIANA, ILLINOIS, KENTUCKY:											
Inventories (Barrels)...1939	4,065,000	3,510,000	2,860,000	2,211,000	2,327,000	2,619,000	3,270,000	3,984,000	4,692,000	4,810,000	.....
Inventories (Barrels)...1940	4,372,000	3,026,000	2,571,000	2,452,000	2,505,000	2,993,000	4,025,000	*4,925,000	.....	.....	6,500,000
Yield Gas & Distillate Fuel (Percent).....1939	.....	11.2	10.8	9.0	9.7	7.8	8.7	9.0	10.6	9.4	.....
Yield Gas & Distillate Fuel (Percent).....1940	.....	12.6	10.9	10.9	9.8	9.9	10.8	.....	.....	.....	.....
Yield Gaso. (Percent)..1939	.....	55.2	54.7	53.7	54.5	52.9	56.1	54.7	56.2	56.5	.....
Yield Gaso. (Percent)..1940	.....	53.3	50.4	51.7	52.9	54.8	53.8	.....	.....	.....	.....
OKLAHOMA, KANSAS, MISSOURI:											
Inventories (Barrels)...1939	1,491,000	1,471,000	1,318,000	1,154,000	1,202,000	1,376,000	1,603,000	1,801,000	1,784,000	1,821,000	.....
Inventories (Barrels)...1940	1,544,000	1,138,000	952,000	881,000	927,000	1,028,000	1,209,000	*1,420,000	.....	.....	2,500,000
Yield Gas & Distillate Fuel (Percent).....1939	.....	11.8	11.6	10.5	9.7	9.6	9.2	9.1	7.7	9.4	.....
Yield Gas & Distillate Fuel (Percent).....1940	.....	14.1	10.6	10.2	9.8	8.9	8.8	.....	.....	.....	.....
Yield Gaso. (Percent)..1939	.....	53.5	54.4	54.2	53.1	53.0	53.1	52.4	53.3	54.3	.....
Yield Gaso. (Percent)..1940	.....	52.2	48.8	51.1	49.8	51.5	53.9	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	27,032,000	37,000,000
Rest of Country	.....	.....	.....	.....	.....	.....	.....	.....	.....	11,106,000	11,000,000
Grand Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	38,138,000	48,000,000

Note: Figures indicated thus (*) estimated, others are U. S. Bureau of Mines.

percent, when compared with the demand for these oils during the last winter period calculated from October 1 to March 31. Exports probably will continue to show a considerable decline with the result that the total demand for these oils may be between 6 and 9 percent greater.

Under these circumstances, the 38 million barrels of these products in storage at refineries and terminals on September 30, 1939, would again prove inadequate. It is my opinion that the 48 million barrels, broken up by districts as shown in Table 6, would result in more economic stock levels during next winter and prevent a scarcity of supply such as threatened in certain areas during last winter.

The East Coast and Gulf Coast districts have made considerable progress toward this end as has the Indiana-Illinois region, but Oklahoma-Kansas seems to be falling behind.

Yields of light fuels in the coastal areas have been consistently higher than last year, and yields of gasoline consistently lower, with the result that on July 31 they had 4 million barrels greater inventories of gas oil and distillate fuel than a year ago. These yields seem to have continued into August and it is my firm conviction that if present trends continue, this area will move into the coming winter season not only better fortified against real cold weather than at the beginning of last winter, but at or very close to the amount of inventories required to assure ample supplies without the necessity of producing large quantities of unnecessary gasoline. Somewhat the same comment can be made with respect to the Indiana-Illinois region but as was intimated earlier the Oklahoma-Kansas area had less light fuels in storage on July 31 this year than last.

Another item of interest in connection with the position in which the industry will move into next winter's heating season is the condition of inventories of unfinished oils. In the coastal region these stocks were built up during the second quarter approximately 2½ million barrels, while in the Indiana-Illinois and Oklahoma-Kansas areas, the increase amounted to approximately 700,000 barrels in each. It is only speculation, of course, but I should not be at all surprised if these increases in unfinished stocks reflected additional quantities of gas oil which could be cracked into gasoline or used directly as light fuels should the occasion arise.

Table 6 contains what I think

APPENDIX 1

Export Shipments of Crude Oil and Principal Refined Products

(Barrels of 42 Gallons)

(U. S. Bureau of Mines Data)

JANUARY TO JUNE 6 MONTHS PERIOD

	1939 (Barrels)	1940 (Barrels)	Percentage Change
Crude Oil	34,949,000	26,415,000	—24.4
Gasoline	23,395,000	13,090,000	—44.0
Kerosene	3,725,000	2,291,000	—38.5
Light Fuels	15,918,000	11,326,000	—28.8
Heavy Fuels	9,377,000	7,710,000	—17.8
Lubricants	5,258,000	6,759,000	+28.5
Total Principal Refined Products	57,673,000	41,176,000	—28.6
Total Exports Indicated	92,622,000	67,591,000	—27.0

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are some rather informative comparisons of yields and inventories in the principal light fuel oil supplying districts so far this year and for 1939.

In an appendix are detailed comparisons by products of the trends of exports during the first six months of this year for those who care to go into greater detail with respect to those figures.

Also included are the results of a study of available aviation gasoline statistics and the export situation as it had existed with respect to that product.

The appendix also contains tabulations of inventories of both gas oil and distillate fuel oil and residual fuels as of comparable dates in 1939 and 1940.

I should not like to conclude this paper without some further reference to the last quarter of this year and the first quarter of 1941.

But, first let me say before going any further, that I recognize the difficulties and uncertainties involved in looking so far ahead at any time and this is particularly so just now. I have done some thinking, however, through next winter and currently have the following general outline in mind.

(1) Domestic demand for motor fuel will probably increase 5.5 to 6 percent. Exports may be down as much as 45 percent with total demand up about 3 percent.

(2) That the present high level of sales of new automotive vehicles may contain some forward buying at the expense of sales in 1941 and particularly in the early part.

(3) Giving the demand for motor fuel during the year ended September 30, 1941, the benefit of the doubt, I think the industry must have a minimum of 85 million barrels of finished and unfinished gasoline in storage on March 31, 1941, in order to operate conveniently and economically.

(4) That there probably will be a tendency on the part of refiners to continue to take somewhat less than normal gasoline yields, and I have placed that figure at about 43 percent.

(5) That if a level of 85 million barrels of gasoline inventories is not exceeded on March 31, 1941, crude oil runs to stills will not have been greater than 3,400,000 barrels daily during the entire period.

(6) That other use of domestic

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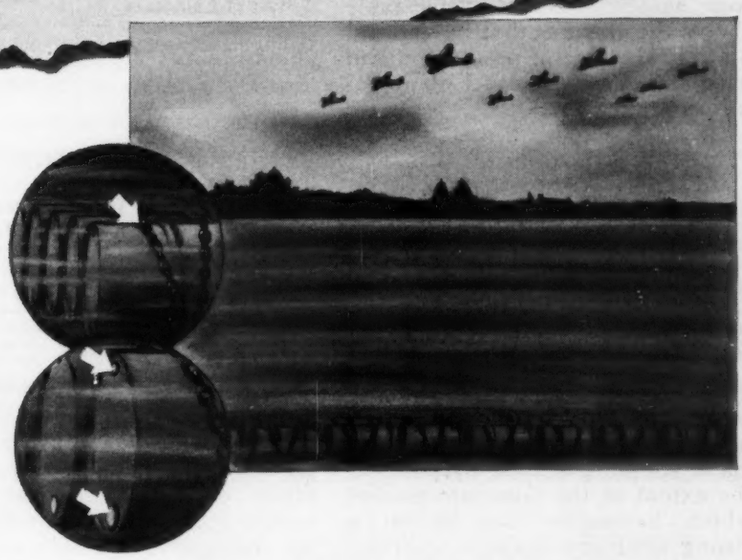

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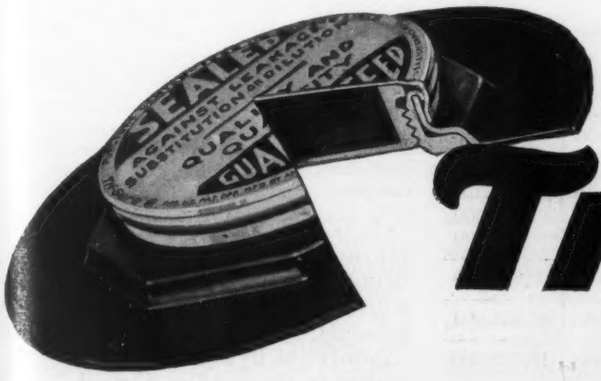

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CLOSURES

crude oil will probably total 125,000 barrels per day and that therefore crude production will not have been higher than 3,525,000 barrels each day during the six months, if the 85-million barrel level is not exceeded.

APPENDIX II
Aviation Gasoline

While domestic demand for aviation gasoline averaged about 400,000 barrels monthly during the first six months of 1940, production climbed steadily and passed the million-barrel mark for the first time in June. Stocks and exports also showed an upward trend reflecting both the accumulation of supplies at home and the increasing demand abroad. November, 1939, is the first month for which statistics were issued. The following table shows the changes that have taken place in the rate of production and exports and in the level of inventories since then.

PRODUCTION	November, 1939 (Barrels)	June, 1940 (Barrels)	Percentage Change
Production	811,000	1,009,000	+ 24.4
Stocks	2,400,000	3,904,000	+ 62.7
Exports	287,000	646,000	+125.1
Domestic Demand	411,000	401,000	— 2.4
Total Demand	698,000	1,047,000	+ 50.0

In view of the embargo on exports of aviation gasoline, total demand for all practical purposes is the extent of the domestic market which heretofore has shown a strong tendency towards stability. If this trend continues, production must depend upon further stock accumulation if it is not to recede to the level of domestic demand. The effect of shifts in international events and policy may be measured by changes in the following data for significant countries which have been buying 75 to 80 percent of the total amount of aviation gasoline exported:

January to June 6 Months Period

Shipped To	1939 (Barrels)	1940 (Barrels)
Netherlands West Indies	422,917	191,301
France	423,258	513,513
Japan	347,495	105,662
United Kingdom	467,412	504,096
Italy	179,839	.....
Non-Contiguous U. S. Territories	128,221	154,259
All Other Countries	635,917	319,929
Total	2,625,059	1,788,760

Similar effects of this trend of exports upon refining areas are revealed in the following table:

January to *May 5 Months Period

Shipped From	1939 (Barrels)	1940 (Barrels)
Texas Gulf	844,014	422,248
Louisiana Gulf	648,249	637,552
California	518,142	107,734
All Other Areas	53,347	46,463
Total	2,063,752	1,113,997

* June breakup by customs district from which shipments during that month were made was not available at time this was compiled.

It is needless to point out that the prospects for aviation gasoline demand depend upon the pace at which national defense measures proceed, the progress of civil and commercial flying and the turn of events in the conflict abroad.

APPENDIX 3
Inventories of Gas Oil and Distillate Fuel
(Barrels of 42 Gallons)

DISTRICT	March 31, 1939 U.S.B.of M.	Sept. 30, 1939 U.S.B.of M.	March 31, 1940 U.S.B.of M.	July 31, 1940 Estimated	July 31, 1939 U.S.B.of M.
East Coast	7,363,000	13,094,000	5,683,000	13,025,000	11,414,000
Louisiana Gulf	816,000	852,000	631,000	1,225,000	1,174,000
Texas Gulf	3,846,000	6,455,000	3,306,000	7,050,000	5,837,000
	12,025,000	20,401,000	9,620,000	22,300,000	18,425,000
Ind., Ill., Ky.	2,211,000	4,810,000	2,452,000	4,925,000	3,984,000
Okla., Kans.	1,154,000	1,821,000	881,000	1,420,000	1,801,000
Inland Texas	273,000	363,000	128,000	230,000	330,000
No. La.-Ark.	193,000	218,000	125,000	195,000	242,000
	3,831,000	7,212.000	3,586,000	6,770,000	6,357,000
Appalachian	268,000	318,000	312,000	360,000	269,000
Rocky Mountain	215,000	227,000	266,000	255,000	215,000
East of California	16,339,000	28,158,000	13,784,000	29,685,000	25,266,000
California	9,560,000	9,980,000	9,302,000	9,815,000	10,074,000
Total United States	25,899,000	38,138,000	23,086,000	39,500,000	35,340,000

APPENDIX 4
Inventories of Residual Fuel Oil
(Barrels of 42 Gallons)

DISTRICT	March 31, 1939 U.S.B.of M.	Sept. 30, 1939 U.S.B.of M.	March 31, 1940 U.S.B.of M.	July 31, 1940 Estimated	July 31, 1939 U.S.B.of M.
East Coast	6,783,000	10,204,000	8,242,000	10,925,000	9,919,000
Louisiana Gulf	918,000	2,373,000	1,084,000	1,550,000	1,891,000
Texas Gulf	5,087,000	8,372,000	6,072,000	6,950,000	7,643,000
	12,788,000	20,949,000	15,398,000	19,425,000	19,453,000
Ind., Ill., Ky.	2,761,000	2,903,000	3,404,000	3,600,000	2,968,000
Okla., Kans.	3,350,000	3,285,000	2,053,000	2,125,000	3,349,000
Inland Texas	2,003,000	2,460,000	1,776,000	1,675,000	2,365,000
No. La.-Ark.	514,000	605,000	356,000	400,000	612,000
	8,628,000	9,253,000	7,589,000	7,800,000	9,294,000
Appalachian	582,000	417,000	764,000	550,000	492,000
Rocky Mountain	616,000	602,000	645,000	600,000	645,000
East of California	22,614,000	31,221,000	24,396,000	28,375,000	29,884,000
California	86,294,000	82,927,000	78,440,000	77,925,000	85,655,000
Total of United States	108,908,000	114,148,000	102,836,000	106,300,000	115,539,000

Good Business Outlook Makes Oil Future Promising

L. J. LOGAN

THE oil industry's outlook is improving because of developments both outside and within the business.

The nation's industrial and commercial activities are proceeding around the highest levels ever reached, and they promise to increase further in coming months, to unprecedented heights, as the huge armament program gathers momentum.

The general business situation therefore is exceptionally advantageous for oil companies, providing a background against which a bright picture in oil might be painted.

Within the petroleum industry, market conditions have been gradually improving during the past few months, in consequence of stricter crude control in the Mid-Continent, the natural decline of Illinois production, more moderate refinery runs, and better adjustment of the yields of refined products, to provide relatively less gasoline and more heating oil, which will be needed in large quantity next fall and winter.

These developments have somewhat alleviated the seriousness of the surplus of gasoline and thereby have promoted a fairly satisfactory over-all situation, as the excessive gasoline stocks have constituted one of the two chief handicaps of the industry.

No early betterment is in sight for lagging oil exports, the other of the two main difficulties confronting the industry, regardless of the future course of the European war. But about 85 percent of the oil export business has been saved (data for June, 1940, compared with June, 1939); and continued growth of domestic business has more than compensated for the loss of foreign sales. (Total demand for U. S. oil was 3.8 percent greater in June, 1940, than in June, 1939, as a 6.8 percent gain in domestic use materially outweighed the 14.7 percent decrease in total exports.) Furthermore, an acceleration of growth of domestic demand is in prospect, in consequence of the national defense program.

When all these general and intra-industry circumstances are considered, it appears that any change henceforth in the oil outlook should be for the better. If business volumes break away from current trends, they should do so on the upside. If crude postings or product prices move away from present levels, the direction should be upward. If oil company earnings assume different proportions, they should expand.

Some significant improvement of the industry's market situation al-

Oil Demand Up This Year Despite Smaller Exports

Figures indicate barrels, and are from Bureau of Mines

	JUNE			FIRST SIX MONTHS		
	1939	1940	Percent Change	1939	1940	Percent Change
SUMMARY						
Total Demand	116,257,000	120,624,000	+ 3.8	676,876,000	712,938,000	+ 5.3
Daily average	3,875,000	4,021,000	+ 3.8	3,740,000	3,917,000	+ 4.7
Exports:						
Crude petroleum	5,831,000	5,692,000	— 2.4	34,949,000	26,415,000	— 24.4
Refined products	10,834,000	8,516,000*	— 21.4	58,883,000	43,716,000	— 25.8
Total exports	16,665,000	14,208,000	— 14.7	93,832,000	70,131,000	— 25.3
Domestic Demand:						
Total domestic demand	99,592,000	106,416,000	+ 6.8	583,044,000	642,807,000	+ 10.3
Daily average	3,320,000	3,547,000	+ 6.8	3,221,000	3,532,000	+ 9.7
TOTAL DEMAND FOR PRODUCTS						
Motor Fuel:						
Domestic	49,812,000	55,459,000	+ 11.3	258,218,000	278,622,000	+ 7.9
Exports	4,459,000	2,581,000†	— 42.2	23,395,000	13,090,000	— 44.1
Total	54,271,000	58,040,000	+ 6.9	281,613,000	291,712,000	+ 3.6
Aviation Gasoline (included above):						
Domestic	‡	401,000	.....	‡	2,402,000	.....
Exports	465,000	646,000§	+ 38.9	2,606,000	1,892,000	— 27.4
Total	.....	1,047,000	.....	.....	4,294,000	.....
Kerosene:						
Domestic	3,570,000	3,952,000	+ 10.7	30,062,000	35,048,000	+ 16.6
Exports	471,000	332,000	— 29.5	3,725,000	2,291,000	— 38.5
Total	4,041,000	4,284,000	+ 6.0	33,787,000	37,339,000	+ 10.5
Gas Oils & Distillate Fuels:						
Domestic	7,187,000	7,327,000	+ 1.9	71,219,000	86,807,000	+ 21.9
Export	2,839,000	2,129,000	— 25.0	15,918,000	11,326,000	— 28.9
Total	10,026,000	9,456,000	— 5.7	87,137,000	98,133,000	+ 12.6
Residual Fuel Oils:						
Domestic	23,923,000	24,749,000	+ 3.5	155,910,000	167,137,000	+ 7.2
Exports	1,684,000	1,959,000	+ 16.3	9,377,000	7,710,000	— 17.8
Total	25,607,000	26,708,000	+ 4.3	165,287,000	174,847,000	+ 5.8
Lubricants:						
Domestic	1,902,000	2,146,000	+ 12.8	11,053,000	11,806,000	+ 6.8
Exports	1,101,000	1,075,000	— 2.4	5,258,000	6,759,000	+ 28.6
Total	3,003,000	3,221,000	+ 7.3	16,311,000	18,565,000	+ 13.8
Wax (pounds):						
Domestic	19,589,000	21,687,000	+ 10.7	131,022,000	146,855,000	+ 12.1
Exports	24,934,000	13,195,000	— 47.2	124,958,000	129,806,000	+ 3.9
Total	44,523,000	34,882,000	— 21.6	255,980,000	276,661,000	+ 8.1
Coke (short tons):						
Domestic	115,600	101,900	— 11.9	668,200	669,400	+ 0.2
Exports	32,600	30,700	— 5.8	116,900	117,000	+ 0.1
Total	148,200	132,600	— 10.5	785,100	786,400	+ 0.2
Asphalt (short tons):						
Domestic	515,200	570,400	+ 10.7	1,918,300	1,885,400	— 1.7
Exports	3,600	35,200	.....	23,800	157,700	.....
Total	518,800	605,600	.....	1,942,100	2,043,100	.....
Road Oil:						
Domestic	1,210,000	1,275,000	+ 5.4	2,753,000	2,387,000	— 13.3
Miscellaneous:						
Domestic	205,000	207,000	+ 1.0	1,113,000	900,000	— 19.1
Exports	8,000	45,000	+ 462.5	48,000	624,000	+ 199.0
Total	213,000	252,000	+ 18.3	1,161,000	1,524,000	+ 31.3

* Exclusive of 15,000 barrels exported from non-contiguous territories but inclusive of 866,000 barrels shipped from U. S. to territories. † Includes benzol, 2,000 barrels in June, 1940. ‡ Not available § Includes 106,000 barrels of anti-knock compounds.

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EASIER WAY TO CLEAN FLAME ARRESTERS

HOW to clean clogged flame arresters was a troublesome problem for one refinery. Methods used were slow, and too costly.

But how the picture changed when Oakite cleaning was put to work! For now, by using solution of recommended Oakite material as directed, even the heaviest and hardest deposits are quickly loosened . . . easily removed with a hose-rinse. Openings are left clear, and plate surfaces clean. What's more, aluminum plates are not harmed. Yes . . . cleaning the Oakite way is SAFE as well as thorough and economical.

Save Money... Save Time ON THESE JOBS, TOO!

On such other jobs as safely descaling Diesel cooling systems and other water-cooled refinery equipment, cleaning interior of tank cars, removing insulating deposits from heat exchangers . . . let Oakite materials and methods point the way to savings. Tell us your problem . . . we can help!

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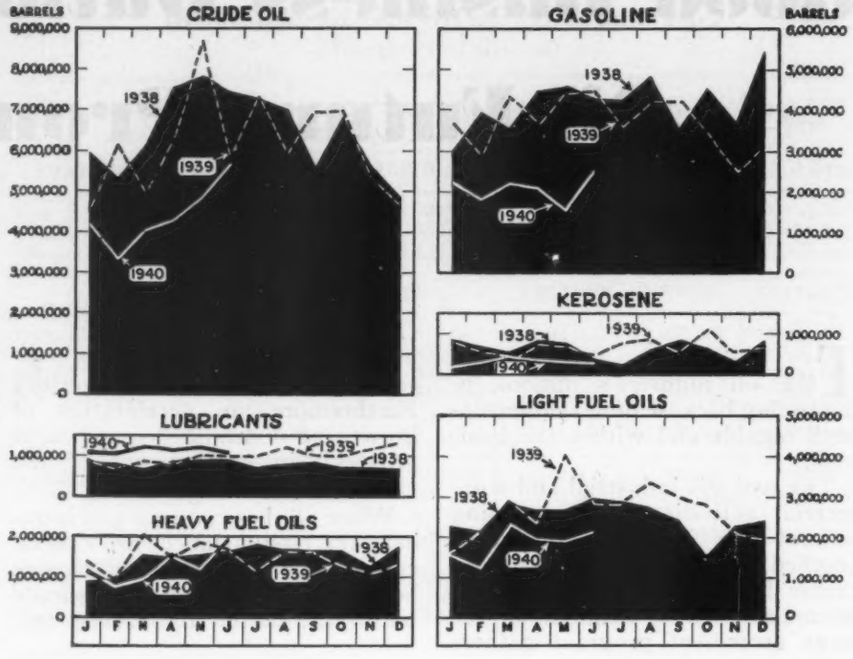
Representatives in all Principal Cities of the U. S. and Canada

OAKITE *Certified cleaning*
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

U. S. Exports of Crude Petroleum and Refined Products



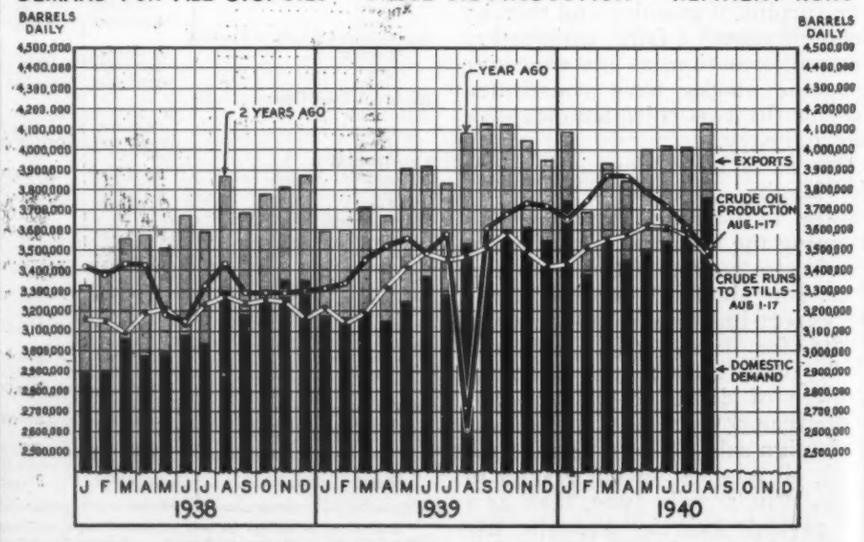
Source of data: Bureau of Mines.

ready has occurred, in fact, within the past few weeks. Illinois crude has been marked up 10 cents a barrel. Sub-normal gasoline prices have been raised in several marketing districts, and refinery prices have shown resistance to any further downward bidding, following the protracted decline to extremely low levels.

The markets for both light and heavy fuel oils have continued firm, inventories of both being quite moderate in relation to prevailing and prospective demand. The coming fall and winter will make large demands on supplies of heating oil; and the speeding up of industrial production through the preparedness program probably will result in record-breaking consumption of heavy fuel oils, with such large users as the railroads, ships, and factories exceptionally busy. Even at this early stage of the re-arming, appreciable expansion of the demand for heavy fuel oil has occurred in the industrial East and Middle West.

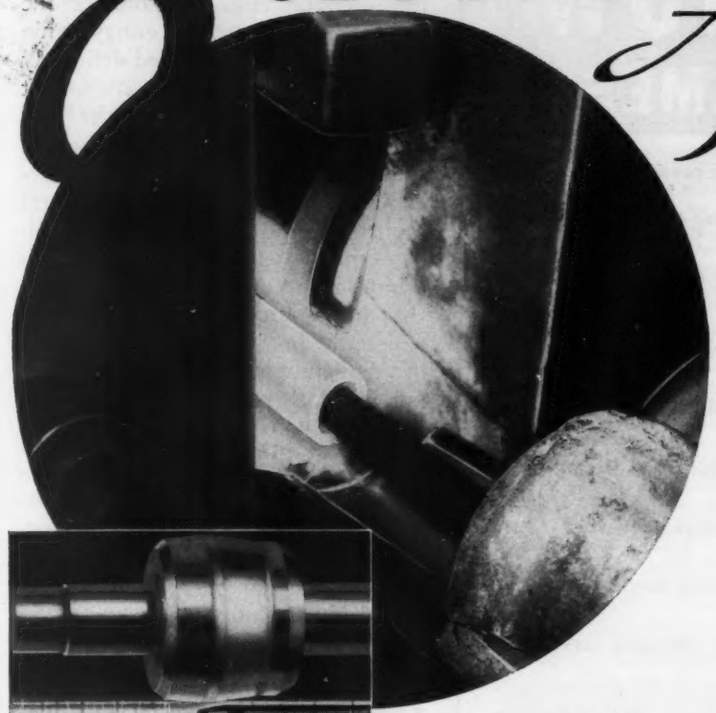
The market for lubricating oil similarly is beginning to feel the influence of the national defense program, having stiffened, particularly in the Pennsylvania district,

DEMAND FOR ALL U.S. OILS - CRUDE OIL PRODUCTION - REFINERY RUNS

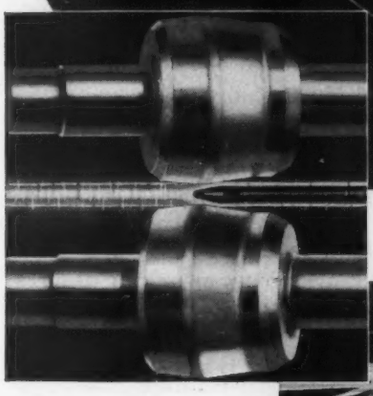


Source: Bureau of Mines except data for July and August, 1940, which are estimates.

8 SECONDS *After Piercing* CRITICAL EYES INSPECT FOR OHIO QUALITY



Billet piercing is an art which OHIO craftsmen have developed by life long practice.



The first of many inspection operations that guard OHIO Quality. It takes an experienced eye to detect the flaws this man would recognize.

OHIO Quality depends on the skill and experience of many craftsmen. Modern Machinery and methods are important — but men trained by years of actual experience are the prime essential.

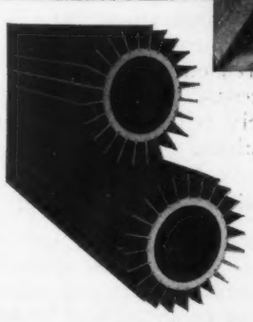
OHIO Quality in the making

Steel Billets of the right analysis and quality for your particular tubing requirements, **sawed** to length, and brought to piercing temperature under the experienced eyes of men who **know** their steel, stop momentarily on their way to the piercing mill as an automatic air hammer locates the center of the billet.

Seconds later that billet comes from the piercing mill as a seamless tube. Rapidly revolving rolls, driven by the force of 1200 horse power, have gripped the glowing billet and forced it against the piercing point, spinning from the solid billet a tube with **seamless** walls of uniform thickness.

Our first critical inspection of the tube is immediately after the piercing operation. Keen eyed Ohio craftsmen inspect the red hot tube both inside and out for any defects that might not be evident when the tube has cooled. Possible mechanical or inherent defects not noticeable in the original billet are then discarded at this point. This inspection is under the control of our Metallurgical Department as a means of double checking their selection of the original steel and in order that all finished tubes will measure up to the high standards of OHIO Quality

The more exacting your requirements, the more you will appreciate this better tubing. Let's talk it over.



The seamless steel tubing used in heat exchangers is usually up against a tough job. Among others who find they can depend on OHIO Quality are the makers of heat exchangers in which transfer of heat is facilitated by inserting fins in the outer surface of the tube. Such construction calls for flawless tubes.

OHIO Seamless
32 YEARS CONTINUOUS OPERATION
SHELBY, OHIO BIRTHPLACE OF Seamless STEEL TUBE INDUSTRY IN AMERICA

The OHIO SEAMLESS TUBE CO.
OHIO SPECIAL QUALITY
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DO YOU KNOW THESE TRADE NAMES?

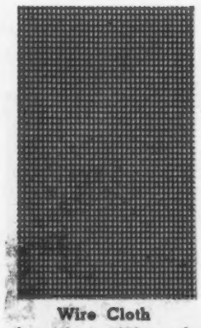
"MULTILEAVES"	Improved type for filter presses
"B.W.D"	(Filter Leaves) for better drainage and cleaning
"SINGLEDISCS"	Up to 25 ft. diam. for claytowers, percolators, waterfilters, etc.
"SMOOTHTEX"	Metallic filter cloth, twilled dutch type
"MULTIBRAID"	Metallic filter cloth, twilled braided type
"SMOOTHBOLT"	Metallic bolting cloth, for fine sifting
"HI-RATIO"	Screens—Long mesh, large open area
"RIBTEX"	Screens—Re-enforced long mesh
"DRUMTITE"	Re-enforced binders for vibrating screens
"WELDEDGE"	Flexible metallic binding

Each one has established a reputation in Refinery Processes for better performance at lower cost

For 29 years we have cooperated with refiners in solving hundreds of seemingly unsolvable filtering and screening problems.

No plant is more completely equipped for the fabrication of wire and screen assemblies than ours, no larger selection of weaves, metals and alloys is carried in stock anywhere.

If intelligent cooperation, speed and accuracy are essential to the solution of your particular problem write us in detail. From the hundreds of case histories tabulated in our "Book of Experience" we can probably offer a quick, satisfactory solution.



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4 mesh to 400 mesh

Filter Cloth
14 x 40 to 50 x 750
In all commercial metals and alloys and in stock widths up to 14 feet.

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ALL MESHES
ALL METALS

in the past two weeks. Since the beginning of this year there have been persistent declines in the prices of lubricants and of the select source, Pennsylvania - grade crude. But Western Pennsylvania refiners have encountered definitely better demand for their bright stocks and neutral oils in the past two weeks and some plants report that they have made contracts covering their output for several months ahead. Further expansion of demand logically would lead to a bidding up of prices. Refiners say that higher prices for products are needed to justify the present prices of Pennsylvania-grade crude, despite the three 25-cent reductions since the early part of this year. But substantial betterment of lubricant prices would bring the prospect of a rebound of the postings for Pennsylvania-grade crude.

General Business Picture

Present circumstances and prospective developments leave very little doubt that general business activity in the United States will be exceptionally brisk in the latter part of this year and for a considerable time thereafter.

The armament program assures for at least two years the greatest activity in the heavy industries since 1929. The program is expected to involve around twice as much government spending as that which caused the business boom of 1936 and 1937.

The heavy expenditures by the government will provide materially increased employment and larger consumer purchasing power, despite increased taxes to cover part of the costs. And practically all lines likely will feel the effects of the stimulant.

Activity at High Level

The implications are especially boom-like when it is considered that business activity generated by the defense program will be superimposed on an already favorable business situation. At the present juncture, industrial production in the aggregate approximates the record levels of 1929, 1937, and late 1939, as the war-related industries are even busier now than last fall, while numerous other lines, including the oil industry, are turning out products in about the same volumes as a year ago. Industries that are less active than in the boom of late 1939 are definitely in

No. 6 OF A SERIES

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LUNKENHEIMER VALVES

for INSTRUMENT LINES, DRAINS AND BY-PASSES

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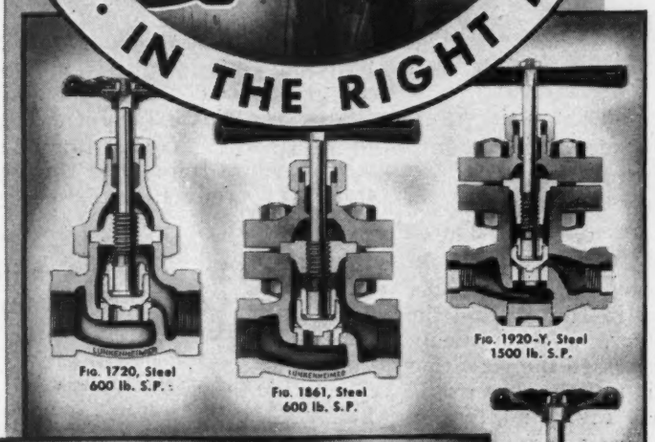

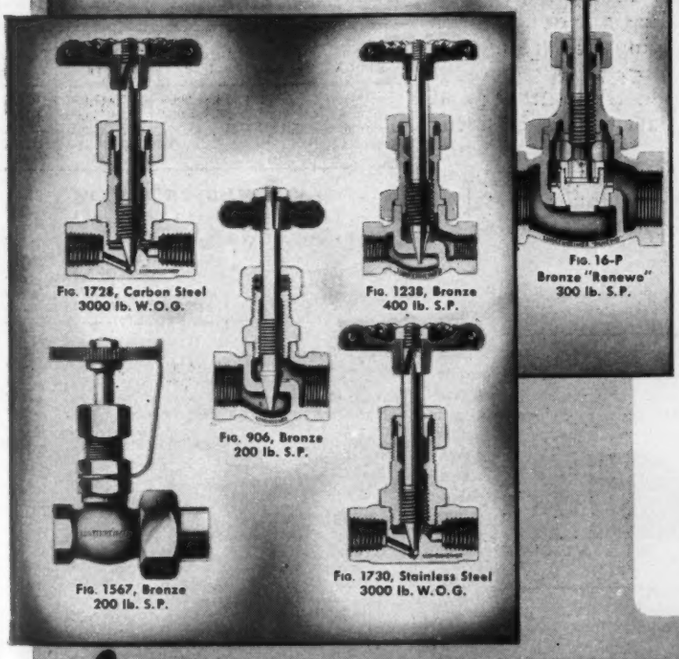

Behind the super-sensitive instruments which guide today's engineer in his constant search for ever-greater operating efficiency and lower operating costs are mazes of pipe lines through which the flow of liquids and gases must be accurately controlled at all times. For such service, only valves of the finest design, materials, and workmanship are worthy of their hire . . . so, it is natural that Lunkenheimer should pay special attention to the production of throttling and needle point valves for every instrument line, drain, and by-pass requirement.

For accurate flow control on all principal lines, Lunkenheimer offers globe and angle valves for all prevailing pressures and temperatures, with a special alloy bonnet-thread-bushing which assures maximum resistance to stem-thread wear under the severest of operating conditions. And for the many small lines where fine regulation of flow is required and compactness is desirable, Lunkenheimer needle-point valves of either bronze or different types of steel provide the right valve in the right place.

SEEING IS BELIEVING!

Your Lunkenheimer distributor will gladly show you the many points where "engineered superiority" guarantees accuracy, safety, and low cost service.

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Illustrated here are only a few of the Lunkenheimer valves particularly suited for instrument line service. Send for Catalog No. 78 showing the entire line, and we'll include our handy "Guide" which facilitates selection according to pressures, temperatures, and service applications.

LUNKENHEIMER

Oil Exports Down 15 Percent in First 10 Months of War

Figures indicate barrels, except as otherwise noted, and are from Bureau of Mines

ITEM	10 MONTHS PERIOD Ended June 30, 1939	Ended June 30, 1940	Percent Change	MONTH OF JUNE 1939	1940	Percent Change
Crude Oil	57,791,000	50,270,000	— 15.0	5,831,000	5,692,000	— 2.4
Products.						
Motor fuel	40,570,000	26,461,000	— 34.8	4,459,000	[6]2,581,000	— 42.2
Aviation gasoline (included above)	[1]2,606,000	[2]2,825,000	+ 8.4	465,000	[7]646,000	+ 38.9
Kerosene	6,353,000	4,994,000	— 21.4	471,000	332,000	— 29.5
Gas Oil and Distillate	24,603,000	21,211,000	— 13.8	2,839,000	2,129,000	— 25.0
Residual fuel oil	15,707,000	13,066,000	— 16.8	1,684,000	1,959,000	+ 16.3
Lubricants	8,200,000	11,256,000	+ 37.3	1,101,000	1,075,000	— 2.4
Wax (pounds)	209,880,000	206,184,000	— 1.8	24,934,000	13,195,000	— 47.2
Coke (short tons)	191,500	214,900	+ 12.2	32,600	30,700	— 5.8
Asphalt (short tons)	41,900	[3]470,200	.....	3,600	35,200	.....
Miscellaneous oils	87,000	687,000	+ 689.0	8,000	45,000	+ 462.5
[4]Total Refined Products	96,479,000	80,198,000	— 16.9	10,834,000	[8]8,516,000	— 21.4
Total Crude & Products	154,270,000	130,468,000	— 15.4	16,665,000	14,208,000	— 14.7

[1] September, October, November, 1938, not included. [2] September, 1939, not included. [3] Beginning January, 1940, includes both manufactured and unmanufactured asphalt; only unmanufactured asphalt being previously shown. [4] Not the sum of the above figures, some of which do not indicate barrels. [5] Exclusive of 15,000 barrels exported from non-contiguous territories but inclusive of 866,000 barrels shipped from U. S. to territories. [6] Includes benzol, 2,000 barrels in June, 1940. [7] Includes 106,000 barrels of anti-knock compounds.

the minority, and they have prospects for improved business in the months ahead.

So far this year, the national income has been about 5 percent greater than that gleaned up to this time last year. Earnings of manufacturing companies for 1940 are expected to be greater than for 1937 and approximately as large as for 1929.

Especially significant for the oil industry is the fact that the automobile manufacturing companies anticipate exceptionally good sales of their 1941 models, which are now going into production. More new cars on the roads will mean increased consumption of gasoline and lubricants.

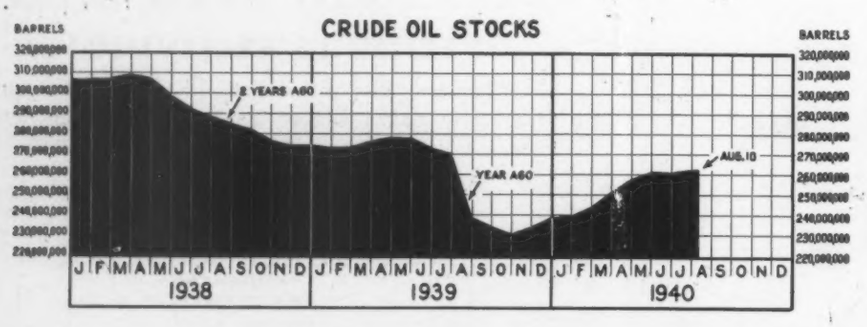
The principal threat to the general business situation is the possibility of British defeat in the European war and a temporary letdown that might result from stoppage of exports to the United Kingdom and from anxiety over adjusting this country's economy to a new order in Europe and the world. However, a government agency has expressed the view that sudden cessation of the war would be "a relatively minor matter" in the business situation. For exports to the United Kingdom are not responsible for more than 2 percent of American industrial output; and a substantial part of the business from Britain involves steel, airplanes, and other military supplies, orders for which would be taken over for the United States defense program in the event of the elimination of the British as customers.

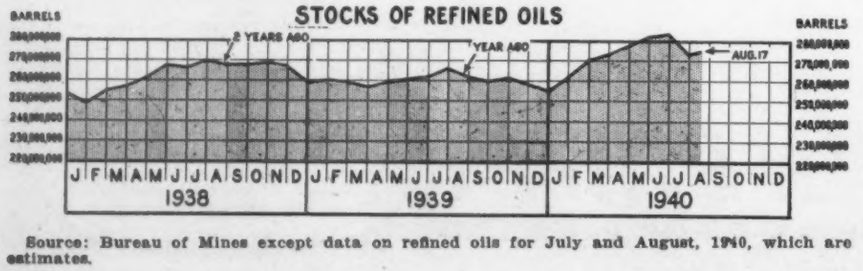
Oil Industry Situation

Despite the two most important handicaps, surplus gasoline and restricted exports, the oil industry occupies a generally desirable position. Total demand for petroleum products continues above last year's curve and therefore highest in the history of the industry, as gains in domestic sales have outweighed losses in export business.

Presented herewith is a table showing how demand, domestic and export, has been in June and the first 6 months of both 1939 and 1940.

Although gains over 1939 were not as large for June as for the first 6 months in the aggregate, the flattening out for the month was not great. Total demand for United States oils was 3.8 percent larger in June, 1940, than in June, 1939, with combined domestic consumption of all products up 6.8 percent,





Source: Bureau of Mines except data on refined oils for July and August, 1940, which are estimates.

Changes from Year Ago in Stocks of Crude and Refined Oils in the United States

(Figures indicate barrels)

LATEST WEEKLY DATA

(Sources: Crude stocks, Bureau of Mines; all other figures American Petroleum Institute)

STOCKS OF:	August 17 1939	August 17 1940	Percent Change
Gasoline	74,822,000	86,441,000	+15.5
Gas Oil & Distillate	36,594,000	42,869,000	+17.2
Residual Fuel Oil	115,580,000	107,935,000	— 6.6
Crude Oil	[1]267,536,000	[2]263,607,000	— 1.5

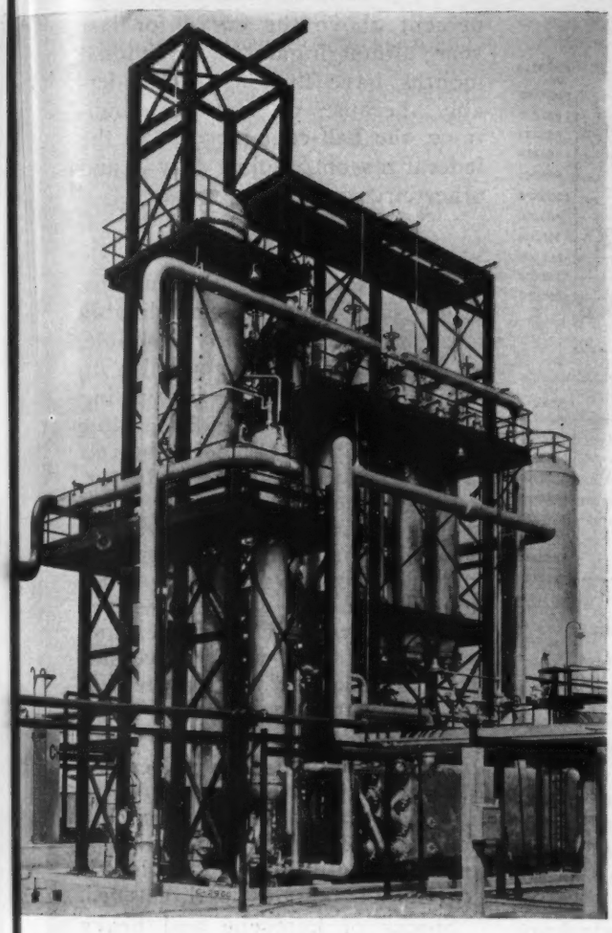
LATEST MONTHLY DATA

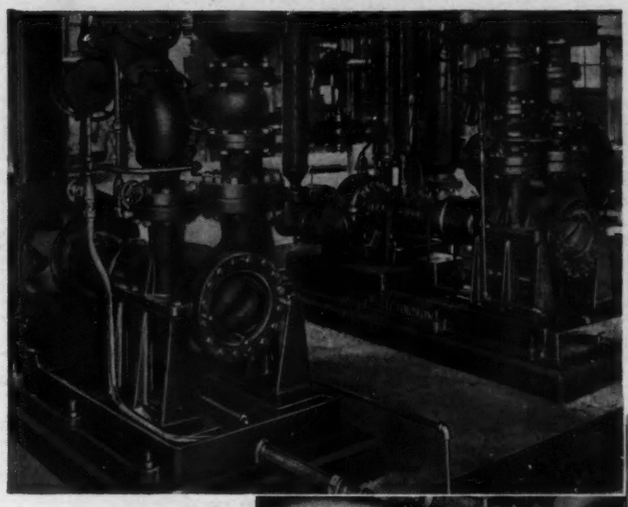
(Source: Bureau of Mines.)

ITEM	STOCKS AT END OF JUNE 1939	1940	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U. S.	273,314,000	261,971,000	— 4.2
Heavy in California	14,207,000	13,334,000	— 6.1
Natural Gasoline	6,749,000	7,000,000	+ 3.7
Refined Products	273,590,000	283,905,000	+ 3.8
Total, all oils	567,860,000	566,210,000	— 0.3
Day's supply:			
June Basis	147	141	— 4.1
6 Months Basis	152	145	— 4.6
PRODUCTS—			
Gasoline:			
Finished	74,395,000	86,276,000	+16.0
Unfinished	5,893,000	7,293,000	+23.7
Total	80,288,000	93,569,000	+16.5
Aviation Gasoline (included above)	[3]	3,904,000	.....
Kerosene	7,949,000	6,810,000	—14.4
[4]Gas Oil & Distillate Fuels	25,659,000	26,412,000	+ 2.9
[4]Residual Fuel Oils	93,322,000	85,448,000	— 8.5
Lubricants	7,427,000	8,161,000	+ 9.9
Wax (pounds)	111,604,000	110,346,000	— 1.1
Coke (short tons)	710,000	697,000	— 1.8
Asphalt (short tons)	642,000	681,000	+ 6.1
Road Oil	1,192,000	1,257,000	+ 5.5
Miscellaneous	280,000	411,000	+46.8
Other Unfinished Oils	38,692,000	41,340,000	+ 6.9

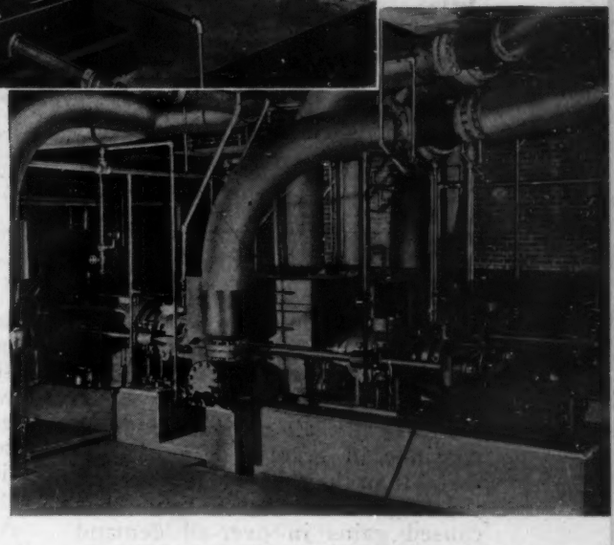
[1] Stocks, August 12, 1939.
[2] Stocks, August 10, 1940.
[3] Not available.
[4] At refineries only.

at Shell-Wood River





Two Worthington Type H centrifugal pumps, in a group of similar units, showing one driven by Moore steam turbine and one by electric motor



Left—Worthington-Carbondale absorption refrigeration unit in alkylation process service

Right—Two of the eight Worthington power-driven hot oil plunger pumps

...indicative of the complete coverage in pumping equipment, air and gas compressors, and power equipment... for practically every operation in the modern refinery.

The steadily increasing demand for Worthington products is the result of consistent performance, year after year, in a wide range of exacting services.

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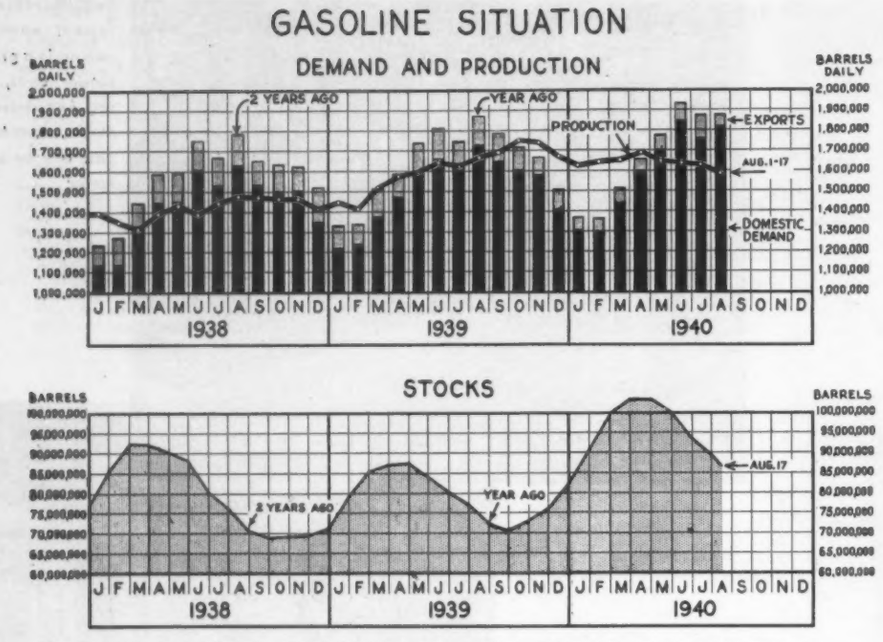
WORTHINGTON


GASOLINE SITUATION
DEMAND AND PRODUCTION
BARRELS DAILY
2 YEARS AGO
YEAR AGO
PRODUCTION
EXPORTS
AUG. 1-17
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940
STOCKS
BARRELS
2 YEARS AGO
YEAR AGO
AUG. 17
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

Source: Bureau of Mines except data for July and August, 1940, which are estimates.

exports of crude down 2.4 percent, and exports of all refined products off 21.4 percent—a decrease of 14.7 percent for all exports.

Practically all refined products continue in greater domestic demand than they were last year, and the larger home consumption has caused gains in over-all demand for most of the major products, including gasoline, kerosene, heavy fuel oil, and lubricants. In June, heavy fuel oil was the only major product exported in greater quantity than a year previously, although lubricant shipments were nearly as great.

For the first 6 months, total demand was 4.7 percent greater in 1940 than in 1939, on a daily average basis, which allows for the extra day of leap year. That gain was the result of a 9.7 percent increase in total domestic demand and approximately 25 percent decreases for exports of crude oil and of refined products in the aggregate.

In the first half of 1940, nearly all refined products were in greater over-all demand than in the similar period of 1939, despite decreases in exports of most products except lubricants and wax. The gains in total demand included those of 3.6 percent for gasoline, 10.5 percent for kerosene, 12.6 percent for light fuel oils, 5.8 percent for heavy fuel oils, 13.8 percent for lubricants, 8.1 percent for wax.

In the first 10 months of the European war, total exports of crude and refined oils were 15.4 percent smaller than shipments in the corresponding months a year previously. Shipments of crude oil were down 15 percent, and those of refined products 16.9 percent, with gasoline most seriously affected, while lubricant exports were stimulated.

Although figures on demand are not available beyond the middle of this year, it is indicated that there has not occurred subsequently any material change in the trends of either domestic or export requirements. The general trend of domestic consumption of gasoline, the industry's principal product, apparently has continued around 6 percent above the curve for last year; although gains for individual months have fluctuated considerably, because of weather conditions, the half-cent increase in the federal tax on gasoline July 1, and other circumstances.

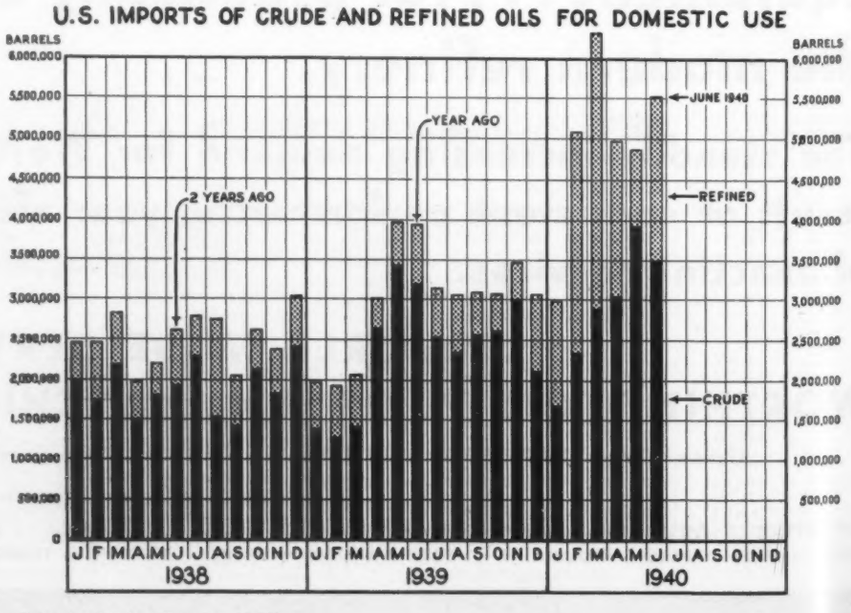
Inventory Situation

With exception of the supplies of gasoline, which are considerably larger than economically desirable, oil inventories are generally in sound relationship to prevailing and prospective demand. Gasoline stocks are about 11,500,000 barrels larger than at this time last year, and that increment wholly represents surplus gasoline, without which the industry could operate quite efficiently. For the stocks held a year ago were themselves considerably in excess of operating requirements and would have sufficed for taking care of somewhat larger demand, such as that which now prevails.

In anticipation of large demand in the fall and winter, the industry has been satisfactorily rebuilding depleted stocks of light fuel oils, and no repetition of last winter's scarcity of supplies is threatened.

Stocks of kerosene and heavy fuel oils are smaller than a year ago, while market requirements are larger. Consequently, markets for those products are firm.

Lubricant stocks are about 10 percent larger than at this time last year, but the inventories are moderate in relation to current and prospective market requirements.


U.S. IMPORTS OF CRUDE AND REFINED OILS FOR DOMESTIC USE
BARRELS
JUNE 1940
YEAR AGO
2 YEARS AGO
REFINED
CRUDE
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

Source of data: Bureau of Mines.

(Continued from page 66)

Last month, members of the National Defense Commission suggested that prosecution of anti-trust suits against the petroleum industry be held up. Recently, events in Washington indicate that indictments will be sought.

It would seem better policy for the Attorney General to make a plea to the petroleum industry. In this he could set forth what seems to be violations of the anti-trust laws and suggest abandonment of the practices. Along with this he could inform the industry that its first duty is to provide the fuels and lubricants needed by the military branches.

Such an attitude will have double benefits. In the first case, any illegal practices will cease. In the second, needed fuels and lubricants will be the quicker and the more cheaply provided. Either of these is of more value than successful prosecution of any industry.

Washington advices have it that the Department of Justice is proceeding with encouragement of results from a national poll, which revealed that a majority of American citizens favor prosecutions. Such a poll may be honest and still not representative.

What officials in Washington need is a few thousand letters from men in the petroleum industry. The men who work in refining plants and natural gasoline plants should let it be known that they are patriotic and that they desire to play a part in national defense, and that they know the corporations for which they work will do a better job if they are not molested in a time when full energy is needed for production.

Having heard from the man on the street, official Washington should hear from the man on the job.

East Texas Company Now Skelly Subsidiary

The East Texas Refining Company, Longview, Texas, became a subsidiary of Skelly Oil Company, Tulsa, following reorganization in August. The reorganization resulted in the election of officials, all of whom are in the Skelly organization.

W. G. Skelly is president; C. C. Herndon and L. F. Brothers are vice presidents; F. T. Hopp, secretary-treasurer; W. K. Cottrell, assistant treasurer, and John R. Scott, assistant secretary. The first four are also directors.

Freeman W. Burford, who has been president of the concern since its organization, resigned August 1.

John R. Thomas will continue as superintendent.

The Look Box

Defense Subject On NPA Program

Relationship of the petroleum industry in the program of national defense will be a part of the program of the thirty-eighth annual meeting of the National Petroleum Association, Hotel Traymore, Atlantic City, September 18, 19 and 20.

The morning of the first day will be given over to meetings of the department of taxation and the department of fire and accident prevention.

In the afternoon the address of N. H. Weber, president, will be followed by the appointment of committees. Subjects for the afternoon are:

Pennsylvania Oils for National Defense, by Cary R. Wagner, The Pure Oil Company.

Washington Observations, by Ray Tucker, Washington correspondent and columnist.

The Future of Our Foreign Trade, by Eugene P. Thomas, president, National Foreign Trade Council.

The report of the nominating committee and the election of trustees will complete the afternoon program. Trustees will meet that evening.

For the morning of September 19 the department of traffic and transportation will consider the subject, The Transportation Act of 1940. The department of manufacture will meet during the morning. For that afternoon the program is:

The Petroleum Economic Outlook, by Joseph E. Pogue, Chase National Bank, New York.

Civil and Military Aviation, by Robert H. Hinckley, assistant secretary, Department of Commerce.

Progress in Preparedness, by W. Averhill Harriman, liaison officer, National Defense Commission.

The annual banquet that evening will have H. V. Kaltenborn, radio commentator, who will give one of his regular broadcasts.

The seaview breakfast the morning of September 20 will complete the program.

Conventions

SEPT. 18–20	National Petroleum Association, Hotel Traymore, Atlantic City.
30	National Lubricating Grease Institute, Stevens Hotel, Chicago.
OCT. 2– 4	American Oil Chemists' Society, Stevens Hotel, Chicago.
4	Western Petroleum Refiners Association, Regional Meeting, Wichita, Kansas.
7–10	American Gas Association, Atlantic City.
7–11	National Safety Congress and Exposition, Stevens Hotel, Chicago.
17–18	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Los Angeles.
25	Western Petroleum Refiners Association, Regional Meeting, Shreveport.
NOV. 1	California Natural Gasoline Association, Los Angeles.
11–15	American Petroleum Institute, Stevens Hotel, Chicago.
DEC. 2– 6	American Institute of Chemical Engineers, New Orleans.
9–14	National Asphalt Conference, Dallas.
11–15	National Chemical Exposition, Stevens Hotel, Chicago.

Petroleum Section of A. C. S. Meeting

Two meetings of the Petroleum Section of the American Chemical Society will be held during the annual convention in Detroit, September 9 to 13. The first meeting will be September 10 and the next September 11. Each will be on the third floor of the Masonic Temple, which will be the place for all convention sessions. The divisional dinner will be held the evening of September 10 and the business meeting will close the meeting of the next day. Per K. Frolich is chairman of the section and C. R. Wagner is secretary.

The program for September 10, a symposium on the contribution of petroleum chemistry to the automotive industry, follows:

The Relation of Asphalt Road Construction to the Automotive Industry, by E. W. Klinger, A. Holmes and R. F. Phillips.

Oxidation of Asphalt and Its Constituents at Service Temperatures, by R. R. Thurston and E. C. Knowles.

Future Needs in Fuel and Oil for Motor Transport, by T. A. Boyd.

Octane Rating Relationships of Asipatic, Alicyclic, Mononuclear Aromatic Hydrocarbons, Alcohols and Ketones, by Gustav Egloff and P. M. Van Arsdell.

Composition of Some Cracked and Polymerized Naphthas, by R. E. Tannich, B. W. Thomas and A. R. Padgett.

Spontaneous Ignition of Hydrocarbons and Zones of Nonignition, by Charles W. Sortman, Arnold A. Beatty and S. D. Heron.

Separation and Composition of a Lubricating Oil Distillate, by M. R. Fenske and R. E. Hersh.

Oxidation of Petroleum Lubricants, by L. L. Davis, Bert H. Lincoln, G. C. Byrkit and W. A. Jones.

On the Mechanism of Wear Prevention by Addition Agents, by Otto Berck, J. W. Givens, A. E. Smith and E. C. Williams.

The Use of Additives in Automotive Lubricants, by F. L. Miller, W. C. Winning and J. F. Kunc.

The Application of Phenolic Compounds and Metal Derivatives Thereof as Lubricating Oil Addition Agents, by O. M. Reiff.

Petroleum products in Industrial and Process Oils, by J. C. Zimmer and E. W. Carlson.

Second Session

The program for September 11, general papers, follows:

Highly Aromatic Petroleum Solvent

Naphthas, by W. J. Sweeney and E. H. McArdle.

Oxidation of Lubricating Oils, Apparatus and Analytical Methods, by M. R. Fenske, C. E. Stevenson, H. A. Rusk, N. D. Lawson, M. R. Cannon and E. F. Koch.

Oxidation of Lubricating Oils, Factors Controlling Oxidation Stability, by M. R. Fenske, C. E. Stevenson, N. D. Lawson, Glenn Herbolsheimer and E. F. Koch.

Some Effects of Chemical Composition on Lubricants Operation in the Region of Boundary Lubrication, by A. W. Burwell and J. A. Camelford.

The Effects of Temperature on the Consistency of Lubricating Greases, by W. A. Lutz.

Naphthenic Acids, Manufacture, Properties and Uses, by Edwin R. Littman and J. R. N. Klotz.

Petroleum Equilibria, by S. W. Ferris.

The Number of Carbon Atoms in Napthene Rings Calculated from Density, by M. R. Lipkin and S. S. Kurtz, Jr.

The Specific Heats of Liquid *cis-* and *trans-*Decahydronaphthalene, by W. F. Seyer and B. R. Mead.

Densities and Refractive Indexes of Liquid Paraffin Hydrocarbons, by Maurice L. Huggins.

The Preparation of Pure Octanes, by Cecil E. Boord and Albert L. Henne.

The Synthesis of Polycyclopentylcyclopentanes, by Gilbert E. Goheen.

Determination and Identification of Organic Halogen Compounds in Mineral Oils, by M. S. Agruss, George W. Ayers, Jr. and H. Schindler.

Determination of Bromine Addition Number, by Karl Uhrig and Harry Levin.

Petroleum Section Safety Program

The program of the Petroleum Section, National Safety Council, will continue through four days of the twenty-ninth National Safety Congress and Exposition, October 7, 8, 9, 10 and 11, Stevens Hotel, Chicago.

Officials of the petroleum section are: C. J. Nobmann, Shell Oil Company, Sacramento, California, general chairman; H. T. Markee, Phillips Petroleum Company, Bartlesville, vice chairman for production; C. A. Miller, The Texas Company, Houston, vice chairman for pipe lines; J. Howard Myers, The Atlantic Refining Company, Philadelphia, vice chairman for manufacturing; F. R. McLean, White Star Division, Socony-Vacuum Oil Company, Detroit, vice chairman for marketing; J. H. Brown, Tide Water Associated Oil Company, New York, program chairman; H. N. Blakeslee, American Petroleum Institute, New York, secretary.

The program of October 7 will begin in the afternoon with reports of the chairman and vice chairmen. Papers for this program will be: Cleaning Tanks Which Have Been Used for the Storage of Leaded Gasoline, by O. B. Lewis, Ethyl Gasoline Corporation, New York.

When and Where and If So What, Fire Regulations Are Needed for Producing Fields, by George F. Prussing, Union Oil Company of California.

Officials will be elected as part of the program for the afternoon of October 8, when the program will be:

Photography as a Visual Means of Education in Accident Prevention, by T. S. Maffitt, Jr., Houston Oil Company, Houston.

Enlisting Employes in the Accident Prevention Program, a panel discussion whose leader will be J. L. Risinger, Socony-Vacuum Oil Company, New York. Participants in the discussion will be J. Howard Myers, The Atlantic Refining Company, Philadelphia; George F. Prussing, Union Oil Company, Los Angeles; J. W. Selch, Cities Service Oil Company, East Braintree, Mass.

The program for October 9 is:

Effect of Legislative Trends on Safety, by F. R. McLean, White Star Division, Socony-Vacuum Oil Company, Detroit.

The Problem of Underground Service Station Tanks, by R. M. Cadman, chairman of the conference committee on leakage of gasoline from underground storage tanks.

Accident Prevention Through the Eyes of an Insurance Executive, by R. M. McDonald, Zurich General Accident & Liability Insurance Company, Chicago.

The final program, October 9, will begin with a luncheon part of which will be the 1939-40 Petroleum Section Safety Contest reports and the presentation of awards. The paper for this program will be:

Outstanding Facts, by H. N. Blakeslee, American Petroleum Institute, New York.

Gasoline Stockpile For Defense Program

Moving swiftly along two lines, Congress and the Administration last week took steps to insure an adequate supply of aviation gasoline for needs of the national defense program.

Definite moves to that end included:

1. Inclusion by the Senate Appropriations Committee of a $3,000,000 fund in the $5,000,000,000 supplemental defense appropriation bill, for the storage of aviation gasoline at various locations throughout the country.

2. Creation of a Defense Supplies Corporation, with a capital of $5,000,000 and a fund of $50,000,000 for the purchase of high-test gasoline.

3. A meeting of a special committee of oil company engineers to advise the Army and Navy on storage systems.

Approval of the $3,000,000 for the construction of storage facilities was given by the Senate committee after Secretary of the Navy Frank Knox had disclosed that plans of the Army and Navy call for a total expenditure of $7,000,000 for storage for sufficient aviation gasoline to meet the needs of the two services for three or four months.

Secretary Knox explained that the Navy proposes to spend $2,500,000 on such facilities while the War Department, which will need twice as much gasoline, will expend $5,000,000.

Constant Reserve

"It is designed to keep this supply of aviation gas pretty nearly normal, he said. "As we use it up, we put additional gas in, so as to keep a steady pool to supply our war necessities for three or four months."

At the present time, the committee was told, the capacity of the industry to supply 100-octane gas is considerably in excess of the peacetime requirements but "that capacity is far short" of meeting wartime needs.

It was indicated that the greater part of these storage facilities would be underground, it being the consensus of defense officials that such storage would be safer from attack and only a little more expensive than surface storage.

Navy officials explained to the committee that the funds for the purchase of gasoline would be advanced by the Reconstruction Finance Corporation, which would be reimbursed by the Army and Navy as gasoline was withdrawn from storage for use. The price paid by the two departments would be slightly more than that paid by the RFC, the surcharge being to cover the latter's expenses in connection with the operation.

At the same time, it was said, the price of gasoline to the two services will porbably be no greater because of the surcharge than if they had bought directly from the refiners, because the RFC will get better quantity prices. At least one company now is building a refinery to manufacture aviation gasoline, Secretary Knox said.

The purchase of gasoline for storage will be carried out through the Defense Supplies Corporation, created by the Reconstruction Finance Corporation. The new organization will have a capital of $5,000,000, the stock to be held by the RFC, and the latter also will advance $50,000,000 for the acquisition of gasoline. This will be in the form of a revolving fund, and as the Army and Navy draw from the stored stocks, additional purchases will be made so that at all times there will be a supply of gasoline sufficient to meet all needs for 100 days.

The storage facilities which it is proposed to construct will be located at strategic points throughout the country, but the sites have not been disclosed.

The meeting of the special engineering committee put under way several weeks of study designed to develop storage systems best suited to the needs of the military services.

Committee Personnel

The committee met with Dr. Robert E. Wilson, chief of the petroleum section of the National Defense Advisory Commission, August 20 for a preliminary discussion of the problem. Also present were Army and Navy officers who will be in charge of their departments' storage operations.

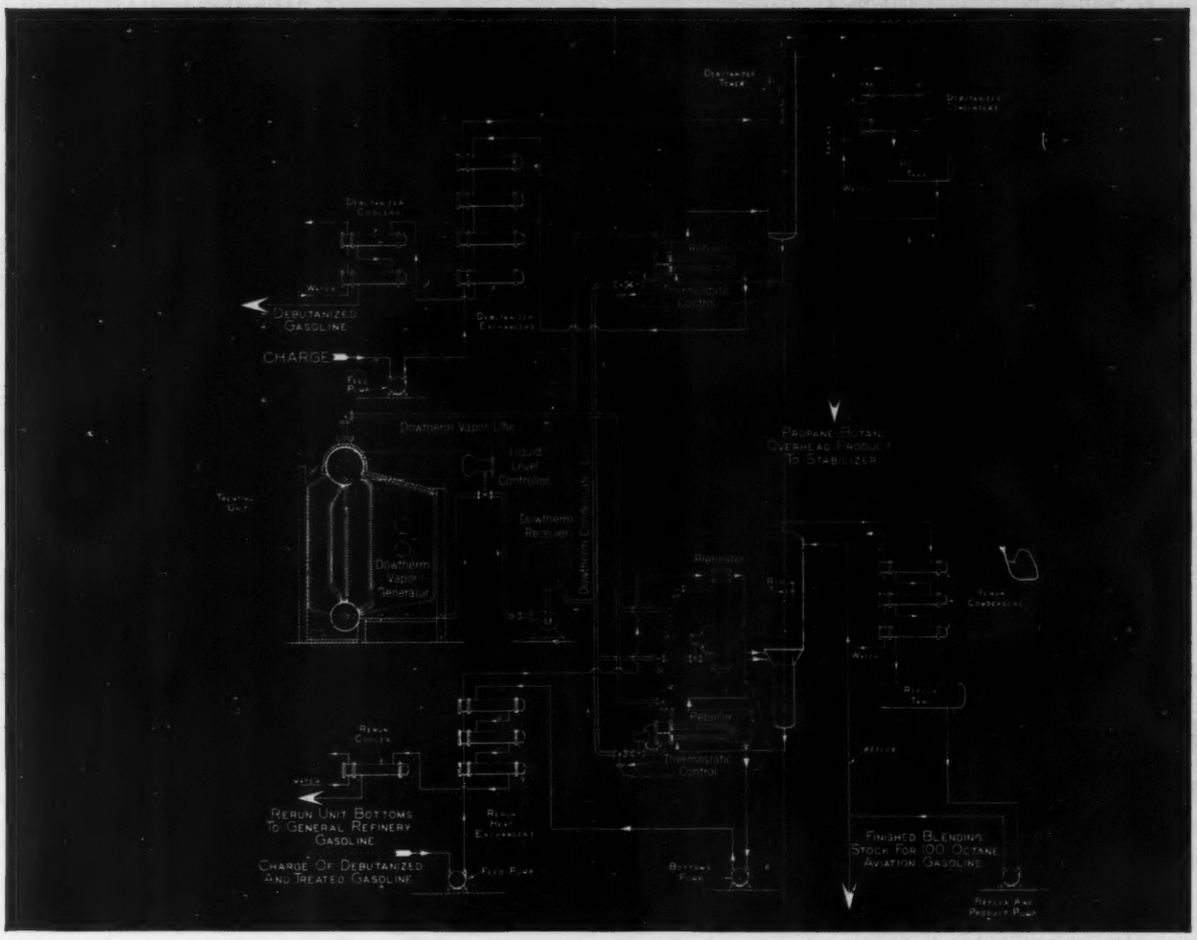
The committee, selected at the request of the two departments, includes Scott E. Drummond, Standard Oil Company of New Jersey; W. B. Engelbrecht, Phillips Petroleum Company of California; S. P. Johnson, Standard Oil of California; O. B. Lewis, Ethyl Gasoline Corporation; C. D. Norris, The Texas Company; Walter Semans, Sun Oil Company, and E. D. Seymour, Socony-Vacuum Oil Company. The group, Dr. Wilson said, are outstanding terminal designers and are being loaned by their companies for service to the government without compensation.

An adequate supply of helium to meet any national defense needs was assured by Secretary of the Interior Harold L. Ickes, who said the Amarillo, Texas plant can increase its production by 50 percent without difficulty.

Steps also were taken during the week to make effective President

PROCESSING OF BLENDING STOCK WITH DOWTHERM

THE HIGH TEMPERATURE, LOW PRESSURE, HEAT TRANSFER MEDIUM


DEBUTANIZED GASOLINE
CHARGE
PROPANE BUTANE OVERHEAD PRODUCT TO STABILIZER
RERUN UNIT BOTTOMS TO GENERAL REFINERY GASOLINE
CHARGE OF DEBUTANIZED AND TREATED GASOLINE
FINISHED BLENDING STOCK FOR 100 OCTANE AVIATION GASOLINE

System developed by Foster Wheeler Corporation

WHERE a processing operation demands accurately controlled temperatures up to 725° F., Dowtherm* vapor low pressure heating offers definite advantages over a wide range of applications.

In the manufacture of 100 octane aviation gasoline, for example, where well-fractioned, selectively-prepared fractions are blended, the maintenance and variation of temperatures is of fundamental importance. Dowtherm heating adequately meets such controlled conditions and at the same time offers a simplified heating system, as illustrated, characterized by its low initial and subsequent low maintenance cost. Here a single Dowtherm vapor generator can be used to furnish all of the heat required for the debutanizer reboiler, the rerun tower reboiler, and the preheater for the rerun tower. The accurate control possible with Dowtherm heating also insures a superior product in increased quantities.

Dowtherm heating systems have made outstanding records for capacity, reliability and safety due to the low pressures involved.

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Roosevelt's embargo on the export of aviation gasoline to destinations outside the Western Hemisphere, and new clearance application forms were put in use at ports of export, which will be forwarded to Washington for approval by the Merchant Ship Control Bureau of the Treasury Department before oil-carrying vessels can clear. Separate forms have been provided for clearances to ports in this hemisphere and for places outside that area, in each of which there is provision for a statement by the collector of customs in event of suspicious circumstances and for his recommendation as to whether clearance should be granted.

Both application forms inquire as to the name, nationality, destination and intended sailing time of the vessel; the name of the owner, the charterer, if any, and whether ownership, wholly or in part, is vested in a country at war or under military occupation. A brief description of the cargo must be given, and on applications for clearance to ports within the Western Hemisphere it must be stated whether or not the ships are armed.

When it is intended to clear ships for destinations outside the Western Hemisphere and the cargo consists in any part of petroleum products, quantities must be shown on the application on a basis of 42-gallon barrels and long tons according to the following classifications:

1. Fuel oil and gas oil (including Diesel oil).
2. Crude, classified as: (a) Blended or California high-octane crude (any material from which by commercial distillation there can be separated more than 3 percent of aviation motor fuel, hydrocarbon or hydrocarbon mixture) and (b) all other crude.
3. Gasoline, classified as: (a) Aviation motor fuel (as defined in the President's regulations of July 26) and (b) all other gasoline (including kerosene and benzine).
4. Lubricating oil, classified as: (a) Aviation lubricating oil (as defined by the President's regulations of July 26) and (b) all other lubricating oil.
5. Tetraethyl lead (as defined in the President's regulations of July 26).
6. Boosters, such as iso-octane, iso-hexane or iso-pentane.

Lower Estimate For September

Believing that the oil industry has topped the peak for 1940, the United States Bureau of Mines on August 20 forecast a market demand in September for a daily average production of 3,624,300 barrels of crude oil, 33,400 barrels below the estimated demand for the current month and 104,100 barrels under the actual demand in September, 1939.

This was the first decrease forecast by the bureau since it predicted that March demand would be under that of the preceding month, although actual production has been declining for more than three months, since a new all-time record of 3,873,400 barrels a day was registered in April.

In its report, the bureau called attention to the efforts of the industry to adjust itself to current conditions, commenting that "real progress has been made by the refining branch of the industry over the past month in adjusting crude runs and gasoline and distillate yields so as to reduce the still abnormally high inventories of gasoline while proceeding with a satisfactory seasonal build-up in distillate stocks."

The bureau pointed out that daily average crude production during the five weeks from July 6 to August 10 was 3,560,000 barrels and runs to stills 3,521,000 barrels, resulting in an increase of an average of 60,000 barrels a day in domestic crude stocks, and indicating a demand of 3,500,000 barrels compared with the bureau's estimate of 3,634,000 barrels. The rapid decline in crude demand over the past month, it was explained, "reflects chiefly the curtailment in refinery activity, although exports, fuel and losses appear to have been much lower than expected."

The export ban on aviation gasoline may result in the additional curtailment of foreign shipments to the extent of several hundred thousand barrels monthly, the report warned, adding, however, that the June total of 2,581,000 barrels of exported motor fuel was "surprisingly high."

"As predicted," the report commented, "the imposition of the half-cent additional federal tax on July 1 spurred refinery shipments late in June, and the domestic demand of 5,459,000 barrels was perhaps two million barrels above what it would have been normally."

The bureau believes, however, that this pre-tax buying should be compen-

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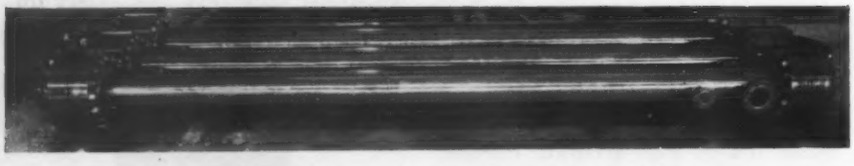

HEAT EXCHANGERS For 2,000 lbs. Working Pressure

Tulsa Boiler & Machinery Co.

WEST TWENTY-FIRST STREET & UNION AVENUE TULSA, OKLAHOMA

sary to combat "dezincification" and where acidity, if any, is of a low order. Red Brass is stronger and stiffer than copper and has excellent resistance to "dezincification" in fresh waters high in temporary and permanent hardness and in soft waters carrying high concentrations of dissolved gases (CO_2 & O_2).

REGULAR ADMIRALTY

Applicable to condensers and other heat exchangers where raw water, whether fresh, brackish or saline, pure or polluted, ranges from moderately acid to alkaline. Regular Admiralty has excellent strength and ductility at temperatures up to 200°C. (390°F.) where a slight drop occurs.

PHOSPHORIZED ADMIRALTY

Wherever dezincification of Regular Admiralty Tubes has been a corrosion problem, the use of Phosphorized Admiralty is suggested. This alloy combines the general excellent corrosion-resistant properties of Regular Admiralty, a desirable fine grain structure, and very marked resistance to dezincification. A large number of Phosphorized Admiralty tubes are now in service and reports of their ability to withstand both general corrosion and dezincification have been very favorable.

ALUMINUM BRASS

This alloy has, in recent years, come into considerable favor. In many installations where tube deterioration results from impingement (erosion-corrosion) attack, it has proved superior to Admiralty. It can be supplied either hard drawn or annealed. Principal uses to date and best performances have been in the marine field and tidewater plants where saline waters are encountered.

CUPRO NICKEL — 80-20

This alloy is economically applicable for severe service in salt or contaminated waters, at relatively high temperatures and under conditions imposing erosion as well as corrosion. 80-20 Cupro Nickel resists sulphur compounds well and finds considerable application in the petroleum industry. It retains good physical properties at high temperatures.

CUPRO NICKEL — 70-30 and ADNIC

These are superior corrosion-resistant alloys, recommended for the most severe conditions in which copper alloys are serviceable. The protective film formation on these alloys is impervious, tough, and continuous. It protects against the chemical or electro-chemical action of the commonly encountered circulating media in power, petroleum, and other process plants. The erosion-corrosion resistance of these alloys is of a high order and has earned for them the distinction of exclusive specification, for use in steam condensers, of several of the world's greatest Navies.

In addition to the proper selection of material we have also observed the very pertinent nature of several other factors affecting tube life and have built up an engineering organization to help in overcoming them. This may take the form of reduction of the severity of tube service by the reduction in velocity of circulating media, the lowering of temperature or decreasing of acidity of the circulating streams, or alterations in design such as improvement in streamline flow, elimination of stagnant zones, better shell side distribution, elimination of entrained or released gases on the water side or reduction of metal stresses.

In some installations only one of these factors will be found, and the solution in such a case is usually clearly indicated — in other installations several factors may be found, each contributing its share toward early tube failure, though some factors will be found to be the major cause of the rapid corrosion and the others contributing only in a minor degree.

The Scovill Technical Condenser Tube Service Department will gladly work with you on any of your condenser tube problems.

These services — the furnishing of most suitable materials and development work on new alloys — assistance in the field in overcoming problems of individual customers — are two of three Condenser Tube services associated with Scovill.

One is Service in Metals. Another is Service in Men. The third is Service in Manuals which inincludes a "Condenser Tubes" Booklet, summarizing much of the knowledge built up by Scovill at home and afield. This booklet shows manufacturing processes and contains sections on tube installation methods, selection of material, specifications and Composition and Physical Properties of Tube Metals. It will be sent, without charge, upon request to Scovill Manufacturing Company, 15 Mill Street, Waterbury, Connecticut.

Condenser Tubes

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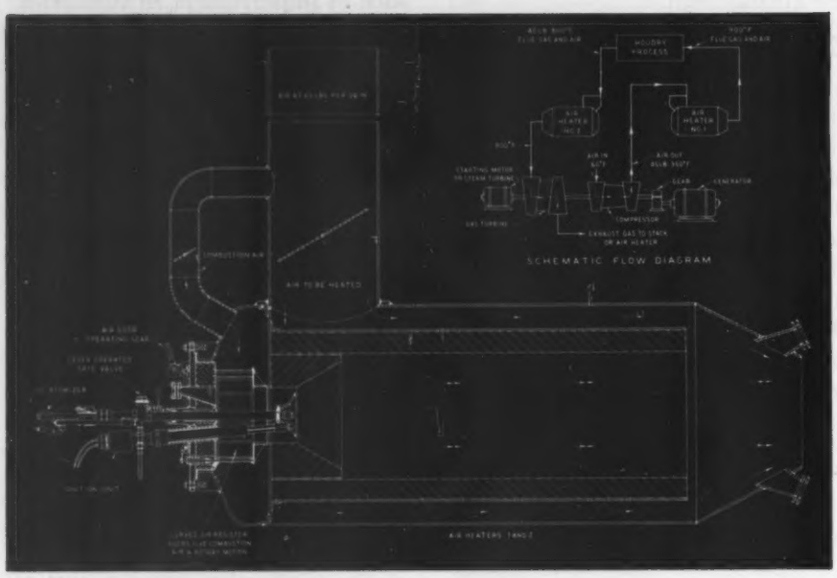
SERVICE IN METALS . . . SERVICE IN MEN

TAKE HOUDRY



AS AN EXAMPLE OF VERSATILITY IN PEABODY BURNER ENGINEERING

THE REMARKABLE HOUDRY CRACKING PROCESS requires large quantities of compressed air at temperatures around 1000° F., to increase the activity of chemical catalysts. This air is heated by burning oil directly in the air stream already compressed to about 50 lbs. per sq. in.

PEABODY supplied oil burners of original design to fire into the supercharged atmosphere and constructed of suitable heat resisting materials to withstand the high temperatures encountered. The Peabody burners proved so efficient and satisfactory that almost every Houdry installation to date has standardized on Peabody Burners.

IT WAS NATURAL for the Petroleum Industry to turn to Peabody when this need arose, for Peabody burners have long met the demands of the refinery for sturdiness, easy and positive regulation, combustion efficiency and long continuous service.

PEABODY manufactures a wide variety of burners to give your desired performance, whatever fuel or combination of fuels you use; whatever furnace design you employ and flame pattern you demand; a type and size for every service.

You will find able and experienced Peabody engineers near you by referring to our list of offices in the 1940 Refinery Catalog.

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sated by reductions in sales in July and August, but probably not in September, and accordingly placed the domestic demand for next month at 52,900,000 barrels, or 7 percent above September, 1939.

Forecasts by the principal exporters of motor fuel indicate that the volume in September will be slightly less than 40 percent of last year, making an estimate of 1,600,000 barrels, compared with 1,900,000 forecast for August.

The report showed that stocks of finished and unfinished gasoline amounted to 93,569,000 barrels on June 30, and that American Petroleum Institute figures indicate that something over 5,000,000 barrels were taken out in July, so that the amount on hand July 31 should have been just over 88,000,000 barrels. It was estimated that an additional reduction of 4,000,000 barrels will be made in September, compared with 6,400,000 barrels for August.

Benzol production and direct sales of natural gasoline are estimated at 1,200,000 barrels, the same as in August, making an indicated refinery production of 49,300,000 barrels, which should be distributed among districts as follows:

East Coast, 6,720,000 barrels; Appalachian, 1,820,000 barrels; Indiana-Illinois, 10,310,000 barrels; Oklahoma, 3,050,000 barrels; Kansas, 2,740,000 barrels; Inland Texas, 3,510,000 barrels; Gulf Texas, 11,620,000 barrels; Gulf Louisiana, 1,390,000 barrels; Inland Louisiana, 860,000 barrels; Rocky Mountain, 1,350,000 barrels; California, 5,930,000 barrels.

Estimating natural gasoline to be blended at refineries at 7 percent of the total refinery production, or 3,450,000 barrels, and the yield of straight-run and cracked gasoline as 43.2 percent, the bureau, applying that yield to the production of 45,850,000 barrels, estimates crude runs at 106,130,000 barrels, or 3,537,700 barrels a day.

Exporters' forecasts indicate that exports of crude petroleum will be considerably higher than generally anticipated, leading to an increase of the bureau's forecast from 3,700,000 barrels in August to 3,900,000 barrels next month. The estimate for fuel and losses is 2,100,000 barrels.

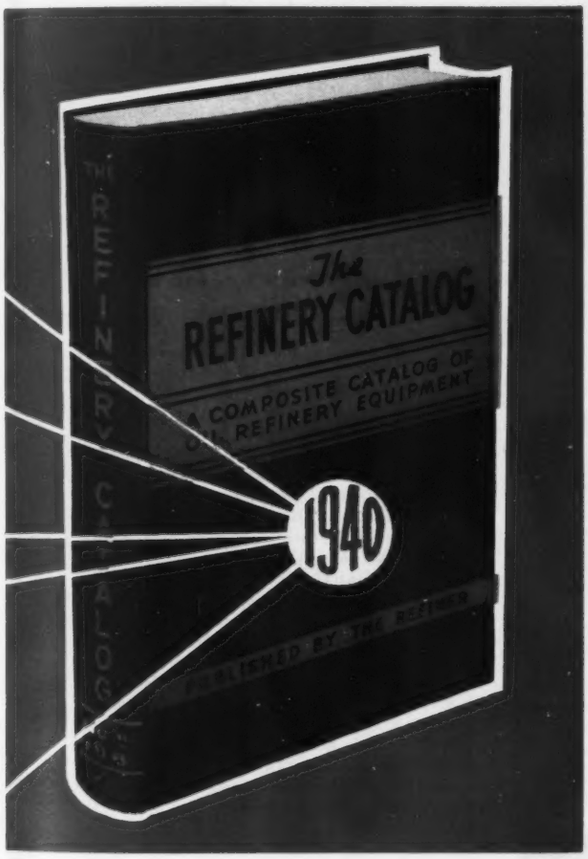
These estimates, the bureau said, indicate a total demand for domestic crude oil in September of 108,730,000 barrels, or 3,624,300 barrels a day, broken down by producing states as shown in an accompanying table.

Bureau Forecast of Crude Oil Demand in September

STATE	Forecast September, 1940	Forecast August, 1940
Texas	1,320,300	1,326,400
California	593,000	598,400
Illinois	430,000	440,600
Oklahoma	397,000	402,600
Louisiana	274,700	276,100
Kansas	170,700	166,800
New Mexico	105,300	105,200
Wyoming	75,300	81,300
Arkansas	69,700	65,200
Michigan	55,700	57,100
Pennsylvania	47,600	48,000
Montana	17,700	20,600
New York	13,700	14,000
Kentucky	13,300	13,900
Mississippi	9,700	10,300
Indiana	9,300	10,000
West Virginia	9,000	9,000
Ohio	8,300	8,000
Colorado	4,000	4,200
	3,624,300	3,657,700

The New REFINERY CATALOG

1940 . . . 9th Annual Edition



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In the new 1940 edition more than two hundred leading manufacturers of refinery and natural gasoline plant equipment filed complete or condensed catalog descriptions and engineering data on their products. This information — compiled by the manufacturers themselves — is up-to-date and authentic, and is arranged for convenient usage. Thirty pages of index and cross-index make it simple for you to find what you want in a hurry.

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The REFINERY CATALOG

A COMPOSITE CATALOG OF OIL REFINERY EQUIPMENT

Division of Petroleum Chemistry Of the American Chemical Society

Abstracts of Papers presented at Detroit, Mich., September 9 to 13, 1940.

The Relation of Asphalt Road Construction to the Automotive Industry

E. W. KLINGER, A. HOLMES, and R. F. PHILLIPS,
Standard Oil Development Co.

The rapid expansion of the use of the automobile has accentuated the demand for improved roads by which the motoring public can achieve greater enjoyment and speed in their driving. This has led to the construction of bituminous road adapted to various traffic conditions and most recently to bituminous soil stabilization. Recent developments in the use of wetting agents permit the construction of bituminous pavements under adverse moisture conditions for which untreated bitumens would be unsuited. The increased mileage of paved roads, largely of the bituminous type, is contributing greatly to riding comfort and lowered cost of car operation and is also affecting the design of the motor car.

Oxidation of Asphalt and Its Constituents at Service Temperatures

R. R. THURSTON and E. C. KNOWLES,
The Texas Company

Under weathering conditions asphalt surfaces undergo oxidation. This photo-oxidation property of asphalt and its constituents has been studied by exposing samples in oxygen-filled sealed Pyrex containers under a sunlamp at temperatures approximating 170° F. The constituents, identified as asphaltenes, resins, naphthene oil, paraffin oil, and wax, were obtained from three typical petroleum residua. All constituents absorbed oxygen, the resin and naphthene oil being slightly more readily oxidized. Constituent source was also a factor. Part of used oxygen was eliminated as water and carbon dioxide, and all residues showed weight increase. Method is applicable to paving and roofing asphalts.

Future Needs in Fuel and Oil for Motor Transport

T. A. BOYD,
Research Laboratories Division,
General Motors Corp., Detroit, Mich.

Chemistry offers the chief assurance that the first need of the future for motor transport, which is a plentiful supply of oil and liquid fuel, will be met. This assurance comes out of all the chemist and the chemical engineer are doing to help find petroleum, to get the maximum amount of oil out of the sand, to refine each barrel of petroleum to best advantage, to utilize fuel and oil efficiently, and also to make coal, oil shale, and vegetation available as reserves for the most distant future.

In gasoline, both for ground and air vehicles, the principal prospect of a further major improvement appears to be in degree of freedom from knock. And freedom from knock depends, of course, upon the chemical constitution of the fuel components. The use of Diesel fuels in automotive vehicles is still too new to point future directions with complete clarity, but the principal improvement will perhaps be in ignition quality. In respect to lubrication, some of the major needs for the future are still better and more stable lubricants and better means of telling whether an oil is good enough for any given service. And this seems to call for a more fundamental understanding of the chemistry and the physics of lubrication.

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Octane Rating Relationships of Aliphatic, Alicyclic, Mononuclear Aromatic Hydrocarbons, Alcohols, and Ketones

GUSTAV EGLOFF and P. M. VAN ARSDELL,
Universal Oil Products Company,
Research Laboratories, Chicago, Ill.

No single standardized motor test method evaluates the nondetonating properties of organic substances in an automobile engine. A correlation of structure with octane rating has been attempted under research and motor method conditions using pure aliphatics, alicyclics, alcohols, and ketones, and a blend of mononuclear aromatics. This study indicates, in part, that for all groups the longer the straight chain part of the molecule, the lower the octane rating.

The tertiary carbon atom also seems to have considerable influence on the nondetonating quality of the hydrocarbon and may be roughly correlated with the influence of the olefin double bond, since as both converge on the center of the molecule the octane rating is raised.

A quaternary carbon if oriented near one end of a paraffin chain also has a great effect in increasing the nondetonating characteristics.

Composition of Some Cracked and Polymerized Naphthas

R. E. TANNICH, B. W. THOMAS, and A. R. PADGETT,
Humble Oil and Refining Company,
Baytown, Texas

Three samples of refinery cracked naphthas representing the products of thermal cracking and polymerization processes were analyzed with the aid of a 115-plate batch laboratory column. The unsaturate contents of representative fractions of these naphthas and the quantities of certain paraffins and naphthenes present have been determined. Methods of analysis and representative examples are presented in detail. The concentration of unsaturates is shown to be greatest at split points between saturated compounds and in general to decrease with increasing boiling point of the cracked naphtha. The gasoline produced by thermal polymerization of propane and butanes shows a higher degree of unsaturation than does that produced by thermal cracking of heavy petroleum fractions such as gas oils and residuums.

Spontaneous Ignition of Hydrocarbons and the Zones of Nonignition

CHARLES W. SORTMAN, HAROLD A. BEATTY, and S. D. HERON,
Research Laboratories,
Ethyl Gasoline Corp.

Spontaneous ignition temperatures in air, and the corresponding time lags, have been determined for a variety of hydrocarbons at atmospheric pressure by the oil-drop or Moore method, using a steel crucible and different air flow rates and liquid drop sizes. Under some conditions of air and liquid feed, the readily-ignited hydrocarbons, such as cetane and heptane, show distinctly two separate temperature zones of nonignition, above the minimum ignition temperature, a behavior heretofore unobserved; under other conditions, one or both of these zones are eliminated. The conditions of air and liquid feed also have a marked effect on the ignition time lag, especially at low temperatures. Addition of tetraethyllead completely inhibits ignition up to about 850 to 1000° F.

Separation and Composition of a Lubricating Oil Distillate

M. R. FENSKE and R. E. HERSH,
The Pennsylvania State College,
State College, Penna.

The systematic separation of a lubricating oil distillate by selective solvent extraction and fractional distillation into portions comprising 0.6 to 1.4 weight percent of the original oil allowed the construction of three-dimensional diagrams incorporating yield, viscosity index, and molecular weight or viscosity. Such diagrams permit an estimation of the distribution of oil fractions with respect to molecular size and molecular type. Used in connection with graphs of boiling point and aniline point isotherms superimposed on the composition diagram, methods for the segregation of any portion of the oil are suggested.

Comparison of the physical properties of the fractions with those of synthetic hydrocarbons indicates that the oil fractions, while perhaps far from being separated into pure compounds, are segregated into groups ranging from monocyclic naphthenes (C_nH_{2n}) to polycyclic aromatics (C_nH_{2n-18}).

Oxidation of Petroleum Lubricants

L. L. DAVIS, BERT H. LINCOLN,
G. D. BYRKIT, and W. A. JONES,
Continental Oil Company, Ponca City

The oxidation of petroleum lubricants is an autocatalytic reaction, the initial phases of which were investigated using an oxygen absorption test. Effects of crude source, refining, accelerators, and inhibitors may be thus studied. Two types of inhibitors are distinguished: true antioxidants and precipitants. The latter only are effective against metallic accelerators. Oxidation products are proximately separable using solvents and adsorption methods. Ultimate analyses of insolubles and oil-soluble resins stepwise separated from used oil show decreasing oxygen contents. Practical engine tests must finally determine the choice of inhibitors. Such tests must finally determine the choice of inhibitors. Such tests emphasize the advantages of certain sulfur-bearing derivatives over simple antioxidants.

The Mechanism of Wear Prevention By Addition Agents

OTTO BEECK, J. W. GIVENS,
A. E. SMITH, and E. C. WILLIAMS,
Shell Development Co.,
Emeryville, Calif.

Using the four-ball bearing both for friction and wear studies, wear prevention agents could be segregated into two classes: wedging agents and chemical polishing agents. Wedging agents comprise those long-chain polar compounds which electron diffraction experiments show to be adsorbed on the metal surface to form highly oriented layers the long carbon chains perpendicular to the surface. Their presence produces a more rapid transition from boundary lubrication to quasi-hydrodynamic lubrication. Chemical polishing agents increase the load bearing surface by corroding off the high points which initially carry the load. Their effectiveness is largest when they form compounds which can combine with the surface to form low melting alloys. Wear reduction factors up to 7 (as compared with white oil) have been found for chemical polishing agents, wear reduction, and factors up to 17 for combinations of chemical polishing and wedging agents.

The Use of Additives in Automotive Lubricants

F. L. MILLER, W. C. WINNING, and
J. F. KUNC,
Standard Oil Development Company

For best performance lubricating oils should have proper volatility, viscosity, stability, oxidation and corrosion resistance, detergency, and lubricating characteristics. In recent years synthetic addition agents have found wide use as means of obtaining these qualities by supplementing conventional lubricating oil refining. Pour point depressants the lower solidification temperatures, thickeners to improve viscosity-temperature relationships, oiliness agents to aid lubricating properties, antioxidants to increase resistance to oxidation and bearing corrosion, detergents to improve engine cleanliness and reduce sludging, and many other special compounds have been developed and utilized. Modern gasoline and Diesel engines, particularly under heavy-duty operating conditions, have created lubricating problems making these special additives essential for satisfactory performance.

The Application of Phenolic Compounds and Metal Derivatives Thereof As Lubricating Oil Addition Agents

O. M. REIFF,
Socony-Vacuum Oil Company

New types of metal organic addition agents for lubricating oils have been developed from alkylated phenolic compounds. By the introduction of alkyl substituents derived from petroleum wax, multifunctional addition agents are formed which are capable of im-

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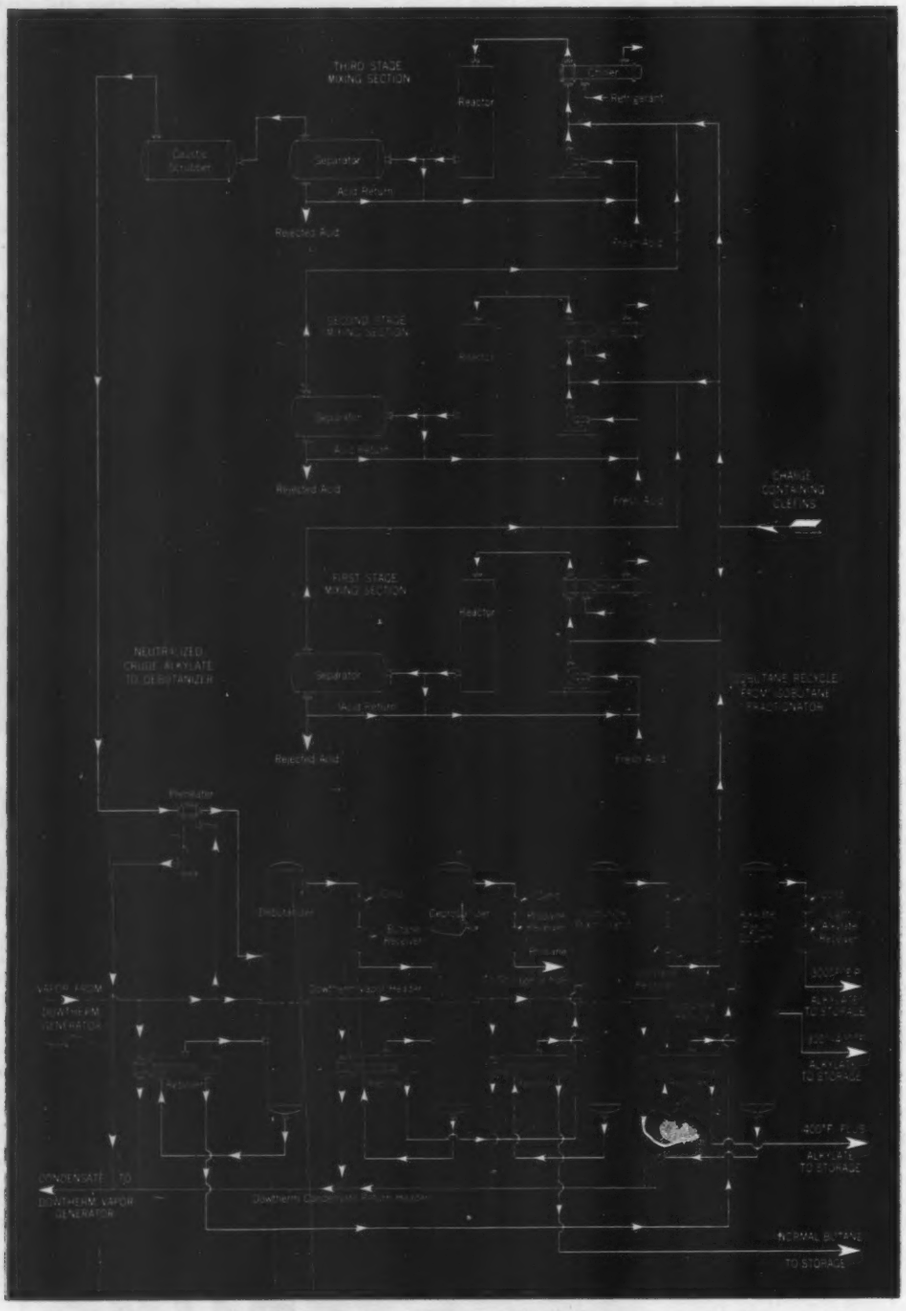

Flow diagram of alkylation process with three stage mixing section

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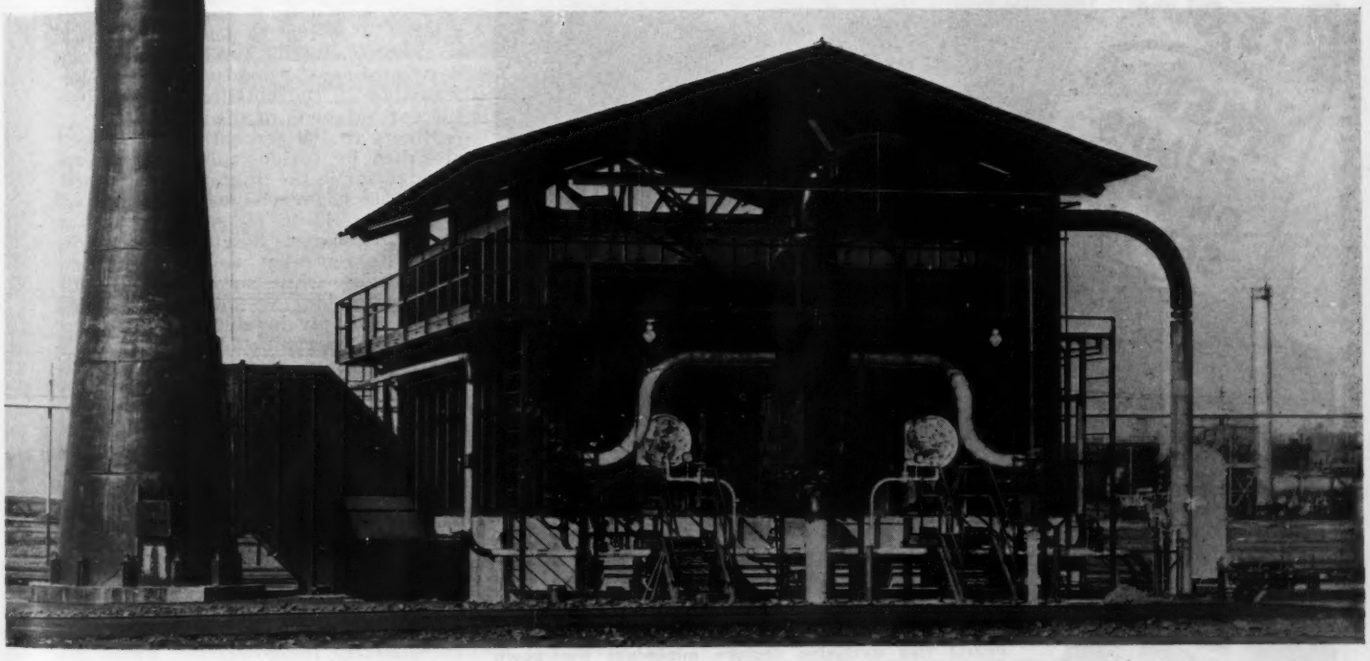

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parting combined properties such as pour point depressant action, improved V. I. and antioxidant value to lubricating oils. The effectiveness of the multifunctional addition agents is improved by the introduction of metal substituents, particularly in respect to antioxidant value. Attention is directed to the importance of the type of solubilizing radical as well as the kind of metal substituent in the formation of metal organic addition agents having antioxidant value.

Petroleum Products in Industrial and Process Oils

J. C. ZIMMER and E. W. CARLSON,
Standard Oil Development Company

Depending on industrial activity, relatively large quantities of petroleum products, comprising an important outlet, are consumed annually in producing lubricating and processing oils in industry, and these oils not only employ petroleum and its by-products, but also utilize large amounts of special compounding materials. Among these materials are emulsifying agents, fatty oils, extreme pressure agents, inhibitors, etc., which help to adapt the oils to a large variety of individual uses. The industrial oils or machinery lubricants are employed largely for the lubrication of steam engine and gas compressor cylinders, and the bearings of turbines and industrial mills. The process oils, either straight, compounded, or made emulsifiable, are utilized in the metal processing industry as cutting oils and rust preventives, etc., and also as components of finished goods, such as textiles, coal, and ink.

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Highly Aromatic Petroleum Solvent Naphthas

W. J. SWEENEY and E. H. McARDLE,
Standard Oil Development Company

The production of petroleum is so great that this material is unquestionably the most economic source of many types of hydrocarbons. Aromatic solvent naphthas represent one type of hydrocarbon concentrate already being produced from petroleum in appreciable quantities. While at present manufactured by physical methods of separation from virgin naphthas, increased quantities can be produced by the application of various hydrocarbon conversion processes. Analysis of commercial aromatic naphthas produced from petroleum has shown aromatic contents ranging from 70 to 90 percent, the principal individual components being toluene, ethylbenzene, xylenes, and mixed C_9 and C_{10} aromatic hydrocarbons and the distribution depending on the boiling range to which the naphthas are cut. Tests made to evaluate the applicability of these aromatic naphthas to coating compositions indicate them to be in general equal in solvency and superior in stability to products derived from coal-tar distillates.

Oxidation of Lubricating Oils. I. Apparatus and Analytical Methods

M. R. FENSKE, C. E. STEVENSON,
R. A. RUSK, N. D. LAWSON,
M. R. CANNON, and E. F. KOCH,
Pennsylvania State College

An apparatus and procedure are described which permit determination of the rate of lubricating oil oxidation. Studies are usually made over the range 130° to 180° C. using oxygen in a circulatory system. Methods have been developed for the determination of substantially all the volatile and nonvolatile end products of the reaction.

Ninety to 100 percent of the oxygen absorbed by various oils has been accounted for in the products determined. The chief product is water, which accounts for 40 to 60 per cent of the reacting oxygen. Soluble saponifiable materials represent another considerable portion, while carbon dioxide, carbon monoxide, volatile acids, fixed acids, and precipitable products account for the remainder.

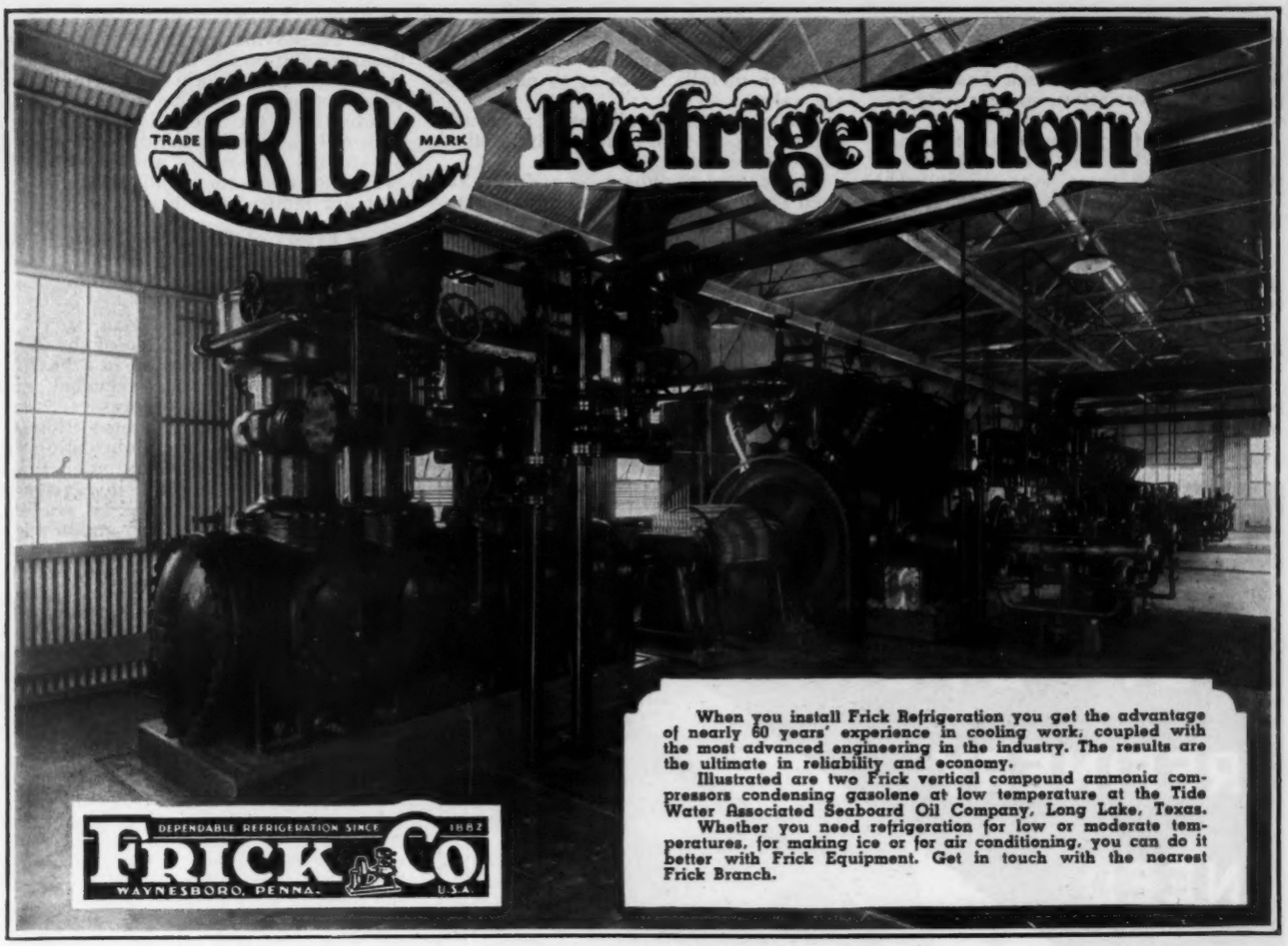
The analysis of insoluble materials produced by laboratory and engine oxidation indicates these to be relatively highly oxygenated materials (14 to 24 percent oxygen) produced by polymerization or condensation of the oxidized oil. Molecular weights and elementary analyses suggest certain empirical formulas for the insoluble bodies.

The oxidation of several commercial light oils shows the rates of oxidation to vary widely and that induction-type oxidation curves may be quite common. In general, these results show the widely different oxidation characteristics existing in oils, and that much of the oxidation mechanism remains to be understood before corrective measures are generally applicable.

Oxidation of Lubricating Oils. II. Factors Controlling Oxidation Stability

M. R. FENSKE, C. E. STEVENSON,
N. D. LAWSON, GLENN HERBOLSHEIMER and E. F. KOCH,
The Pennsylvania State College

A study of the oxygen absorption characteristics and the nature of the products obtained from oils oxidizing under controlled conditions has permitted the evaluation of a number of fac-



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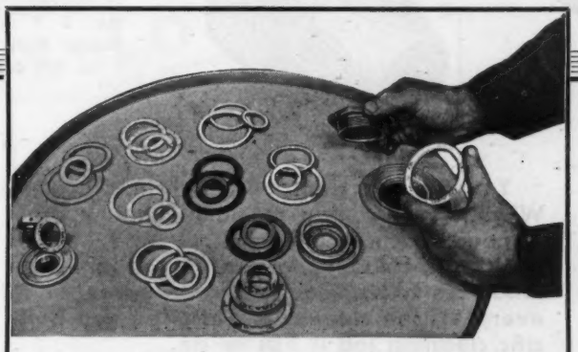

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tors involved in lubricating oil deterioration. Investigation of selected fractions of a distillate stock has shown considerable variations in reactivity toward oxygen.

The rate of oxygen absorption approximately doubles for each 10° C. temperature increase over the interval 140° to 180° C., providing it is not limited by physical factors.

The presence or absence of water vapor in the oxidizing atmosphere has little effect on the oxidation of one type of oil.

It has been found possible to reduce greatly the oxidation of certain oils by adding natural or synthetic inhibitors.

Clay treatment may either reduce or improve the stability of an oil, depending upon its nature.

Iron, copper, and lead are strong catalysts for oil oxidation when present either in metallic form or as naphthenate salts.

Certain types of oils have a natural ability to counteract the catalytic effect of dissolved iron salts.

The use of a phosphite additive has been found to control or eliminate catalysis by certain iron, copper, or lead salts, but such additions are frequently accompanied by other changes in the oils, so that the over-all effect is more complex than simply a reduced degree of oxidation.

Addition agents are capable of making marked changes in the degree of oxidation occurring in oils. They may also influence the direction and character of other accompanying reactions, such as polymerization, condensation, decarboxylation, dehydration, etc., with the result that many of the oxidation products may now be affected independently of the over-all degree of oxidation. In general, addition agents must be studied thoroughy and in detail in order to understand all the changes that are induced by their presence.

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Some Effect of Chemical Composition of Lubricants Operating in the Region of Boundary Lubrication

A. W. BURWELL and
J. A. CAMELFORD,
Alex Corp., Niagara Falls, N. Y.

Determinations are made of the force required to initiate motion in a bearing system at rest, under specified and controlled conditions of pressure, temperature, and lubricant compositions.

Since hydrodynamic lubrication is impossible in the system under these conditions, the factors involved in boundary lubrication may be studied, particularly the effects of small additions of substances frequently used to increase oiliness and film strength effects.

Results are given of determinations made upon lubricating oils blended with agents of the type described above, and comparisons made. The mechanism of the surface activities is briefly discussed.

The Effect of Temperature on the Consistency of Lubricating Greases

W. A. LUTZ,
Gulf Research & Development Co.

The characteristics of a number of representative greases of various types were determined on a modified Bingham plastometer. The yield values of the greases were determined by extrapolation on logarithmic coordinate paper while apparent viscosities were calculated from the Poiseuille equation for purposes of comparison. An example of slippage or plug flow is discussed.

Structural changes in all greases are evidenced by sudden changes in the slope of the apparent viscosity-temperature curve. In certain temperature ranges, sodium and aluminum base greases show increases in apparent viscosity with rising temperature due to their transition from plastic solids to viscous liquids of anomalous viscosity characteristics.

Naphthenic Acids.
II. Manufacture, Properties, and Uses

EDWIN R. LITTMANN and
J. R. M. KLOTZ,
Stanco Incorporated

The expanding uses for naphthenic acids have made desirable a compilation of information regarding their occurrence, manufacture, composition, properties, analysis, and uses. The material presented in this paper is illustrative and organized according to the above subjects and has been collected mainly from the patent literature. Since, in a presentation of this type, a detailed discussion of every reference is precluded, a supplementary bibliography has been appended.

Petroleum Equilibria

S. W. FERRIS,
The Atlantic Refining Company,
Philadelphia, Penna.

Evidence is presented indicating (1) that, regardless of extreme variations in conditions, synthetic crudes resulting from pyrolytic treatment of petroleum or petroleum fractions approach a definite boiling range equilibrium; (2) that the same is true for many processes often considered radically

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different from ordinary pyrolysis; (3) that the synthetic crude may be made to depart from this equilibrium only by carrying the reaction to the point of severe hydrogen impoverishment, after which a second equilibrium is approached; (4) that natural crudes seek the same equilibrium.

The Number of Carbon Atoms in Naphthene Rings Calculated from Density

M. R. LIPKIN and S. S. KURTZ, JR.,
Sun Oil Company,
Marcus Hook, Penna.

Densities for pure compounds containing three and four rings per molecule of either the cyclopentane or cyclohexane type are shown to agree with the curves of Kurtz and Lipkin relating density to molecular weight and ring structure. For groups of similar compounds these average pure compound data agree within ± 0.2 carbon atom per ring.

The Specific Heats of Liquid Cis and Trans-Deca-Hydronaphthalene

W. F. SEYER and B. R. MEAD,
The University of British Columbia,
Vancouver, Canada

The specific heats of *cis* and *trans*-decahydronaphthalene have been measured by means of a modified form of Williams and Daniels adiabatic calorimeter over the temperature ranges from 25° to 150° C. At 30° C. the specific heats of the *cis* and *trans* forms are 1.67 and 1.66 j/gm/c°, respectively. Specific heat of the *trans* form is a linear function of the temperature, while the *cis* behaves in an irregular manner with the temperature. The irregularities are compared with those found in other measurements of physical properties.

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Densities and Refractive Indices of Liquid Paraffin Hydrocarbons

MAURICE L. HUGGINS,
Eastman Kodak Company,
Rochester, N. Y.

Molal volumes (V = mol.wt./density) of normal paraffins are accurately given by the equation, $V_n = 26.96 \pm 16.49_n + \frac{29.0}{n}$. For certain types of non-normal paraffins, V differs from V_n by a small constant, characteristic of the type. Molal refractions [$R = (n_D - 1)V$] can be computed additively from constants characteristic of the types of bonds (primary, secondary, tertiary and quaternary carbon atoms being considered as nonequivalent) or from the equation:

$$R = 7.815n \pm 1.06N_{CH_2} - 1.46N_{CH} - 3.02N_C - 0.10N_{CH\cdot CH} - 0.35N_{C\cdot C} - 0.20N_{CH\cdot C} + 0.20N_{CH\cdot CH_3} + 0.30N_{C\cdot CH_3}$$

Indices of refraction calculated from this relation, using either experimental or computed densities, agree with the observed values to within a few units in the fourth decimal place, on the average.

The Preparation of Pure Octanes

CECIL E. BOORD and
ALBERT L. HENNE,
Ohio State University

Pure hydrocarbons in batches of about 7 liters have been synthetically prepared for examination of their behavior in internal combustion engines. All impurities have been carefully eliminated in order not to upset the knock measurements, particularly the lead response. The equipment has been built from simple standard parts, and the raw materials used have been easily available products throughout; the methods of operations and the resulting yields are listed. The purity of the final samples has been checked by inspection of the freezing curves. Separate measurements performed by the Bureau of Standards have confirmed the results, and their purity rating is appended.

Detection, Determination, and Identification of Organic Halogen Compounds in Mineral Oils

M. S. AGRUSS, GEORGE W. AYERS, JR., and H. SCHINDLER,
The Pure Oil Company

The total halogen is determined by means of the Parr oxygen bomb in which the hydrogen chloride formed during combustion of the mineral oil is absorbed in sodium bicarbonate solution (in the bomb) which in turn is titrated with standard silver nitrate solution by the Mohr method.

Halogen attached to an aromatic ring does not react with 1 *N* alcoholic potassium hydroxide solution when the sample is heated with this reagent for exactly 5 minutes; an exception is the case of iodine with a positive group such as carboxyl or aldehyde in the ortho position. Practically all other organic halogen compounds are attacked by this reagent and the sensitivity of this test is given for halogen compounds in lubricating oil.

The Synthesis of Polycyclopentylcyclopentanes

GILBERT E. GOHEEN,
Sun Oil Company,
Experimental Division,
Norwood, Penna.

For the purpose of establishing the physical properties characteristic of polycyclic 5-carbon membered rings in the light of any probable relationship to the chemical structure of petroleum products, there has been synthesized a series of polycyclopentylcyclopentanes.

Bicyclopentyl, 1,3-dicyclopentylcyclopentane, and 3,3'-dicyclopentylbicyclopentyl have been synthesized from

THE CHOICE FOR CONTROLLING SPECIAL GASOLINE TREATMENT

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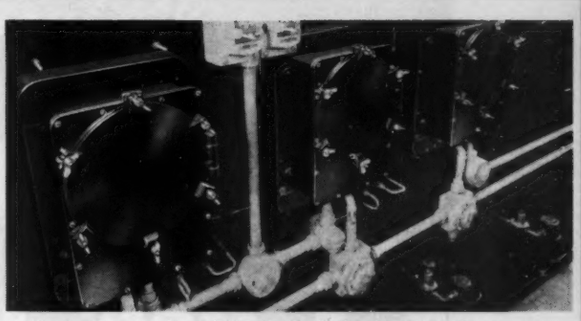

Rear view of three Bristol's Explosion-Resisting Pyromaster. Pyrometers installed in the gas plant of a major refinery.

Bristol's Pyromaster Electric Thermometer Air-Operated Controller and Recorder

The Pyromaster Electric Thermometer is a modern development in the field of temperature measurement and automatic control. It operates on the potentiometer principle and has many outstanding features that make it a highly desirable instrument for controlling modern plant processes.

1. The temperature-sensitive element is small, regardless of the length of the connecting leads, and can be inserted at points where only a limited amount of space is available, such as in small pipe lines. The temperature-sensitive element can be easily replaced on the job should it become damaged.

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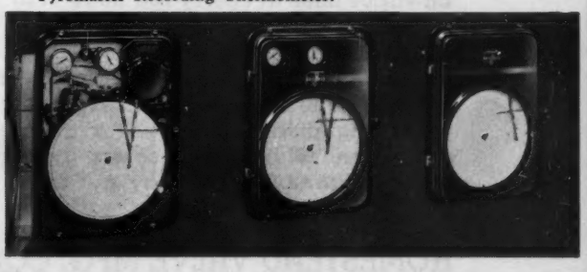
Another installation of Bristol's on important petroleum processing,—from left to right (*a*) Pyromaster Resistance Thermometer, (*b*) Pyromaster Temperature Recorder Controller, and (*c*) Pyromaster Recording Thermometer.



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cyclopentadiene and cyclopentanone, 1,3-Dicyclopentylcyclopentane has also been synthesized from cyclopentanone itself.

Determination of Bromine Addition Number

KARL UHRIG and HARRY LEVIN,
The Texas Company, Beacon, N. Y.

A method is described for determining degree of unsaturation quickly, by direct titration of sample dissolved in chloroform with a standard solution of bromine in glacial acetic acid, using the color of the bromine itself as indicator. It has given correct results when applied to pure hydrocarbons of known unsaturation, such as cyclohexene, diisobutene, triisobutene, etc., and reproducible results on unknowns.

▼ PLANT ACTIVITIES ▼

Magnolia Building Gasoline Line: Along with enlarging its Fort Worth, Texas, refinery from 5000- to 20,000-barrel daily capacity, Magnolia Petroleum Company will build a gasoline line from the plant to Oklahoma City. Contract has been let, and the 200 miles of 4½-inch line will be under construction shortly. The line will have several stations from which products will be transported by truck and rail.

Poly Plant Completed: The Texas Company put a catalytic polymerization plant in operation at its Casper refinery in August. The unit operates on gases from skimming stills of 7000-barrel capacity and cracking stills of 7200-barrel capacity.

Plant Resumes: Quaker State Oil Refining Corporation has made repairs to its Farmers' Valley plant, damaged by fire, and it is now back on stream.

Clay Treating at Texas City: Republic Oil Refining Company has put into operation at its Texas City refinery a new clay-treating installation. This installation, installed by Gray Processes Corporation, will be used to refine cracked gasoline produced by a recently completed additional cracking plant.

Modernization at Eldorado: Skelly Oil Company has announced an estimated $250,000 expansion and remodeling program for its refinery at Eldorado, Kansas. Chief project will be remodeling of two cracking units in the 21,000-barrel capacity refining plant. A gasoline recovery unit also will be enlarged. Work will begin about November 1st.

Recycling at San Salvador: Gulf States Oil Corporation is reported planning a $250,000 recycling plant for the San Salvador gas and distillate field of Hidalgo County, Texas, with the first unit to be started shortly. The company has completed two wells in the field.

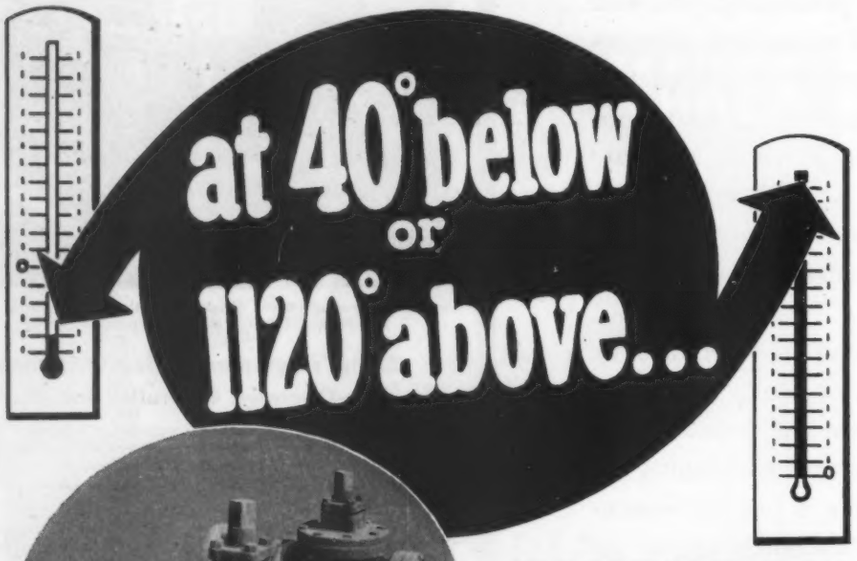
Ohio Standard Modernizes: Standard Oil Company of Ohio has announced a $1,000,000 expansion and modernization program for its refineries at Cleveland, Lima and Latonia. Construction work has started on a catalytic polymerization unit and additional storage at the company's No. 1 plant at Cleveland, and similar improvements will be made at Lima and Latonia.

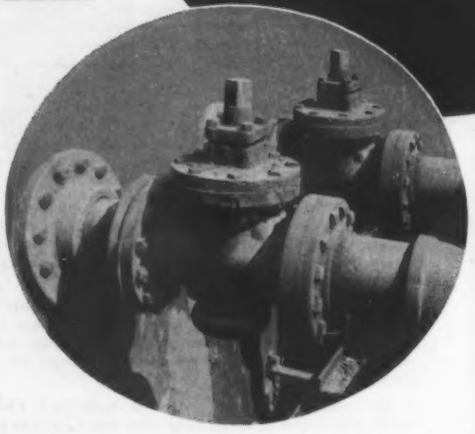
Reforming at Newcastle: Consumers Oil & Refining Company, running Lance Creek and Osage crude at Newcastle, Wyoming, has completed a reforming unit and tankage to bring its storage capacity to 3,000,0000 gallons.

Improvements at Pampa: Danciger Oil & Refineries, Inc., Tulsa, is converting the cracking unit at its Pampa, Texas, refinery to operate the Dubbs cracking and reforming processes. The unit will be of the 2-coil selective type, residuum flashing, with stabilizer and absorber equipment. A Universal Oil Products Company catalytic polymerization unit also is being installed. Rated capacity of the plant will be 3000 barrels of topped crude, with reforming capacity of 900 barrels a day. The poly unit will process about 620,000 cubic feet of cracked gas a day to produce polymer gasoline. Fred Shryock is refinery superintendent.

Gas Purification: The Girdler Corporation, Louisville, Kentucky, has announced eight gas purification plants as recently completed or under construction.

For the purifying of feed stock at its new thermal polymerization plant at Wichita Falls, Texas, Continental Oil Company has installed a Girbotol plant. A similar installation is under way for Lion Oil Refining Company at El Dorado, Arkansas. At Midland, Michigan,





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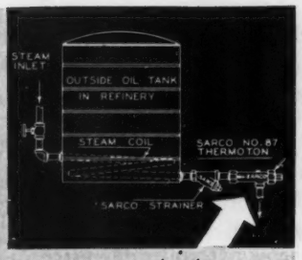

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a plant is under construction for Dow Chemical Company for removal of hydrogen sulphide from hydrocarbon gas. A Girbotol plant for scrubbing carbon dioxide and water vapor from natural gas at East Ohio Fuel Gas Company's new gas liquefaction plant at Cleveland is under construction.

In West Virginia, plants for removal of hydrogen sulphide from natural gas have recently been completed by both United Carbon Company and Godfrey L. Cabot, Inc., while United Fuel Gas Company has converted its dehydration plant at Clio to a combination dehydration-desulphurization unit employing the Girbotol process. Another natural gas purification plant is that of Tri-Ess Corporation in the Amargoza field in Texas.

Cosco Resumes: Cosco Refining Company was scheduled to resume operations early this month at its plant at Wynnewood, Oklahoma. Reconditioning of the plant was in progress in August. It had been shut down since late in 1938. Joe Ernest returns as superintendent, and the plant has a capacity of 2000 barrels daily.

Improvements at Arp: Independent Refining Company is converting its 1500-barrel capacity cracking unit at Arp, Texas, to operate the Dubbs process. Absorber and stabilizer equipment and a Universal Oil Products Company catalytic polymerization unit are being included in the installation. C. W. Curtis is manager of operations, and C. Zimmerman is refinery superintendent.

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No Registration For Oil Stills

By action of the United States Treasury, refining stills were removed from the list of stills to be registered by the department. Inclusion of refining stills was in effect an oversight, since the law was passed for the purpose of listing liquor stills.

The removal was accomplished by this addition to section 2810 (a) of the Internal Revenue Code:

"Stills and distilling apparatus set up at refineries for the refining of crude petroleum or the production of petroleum products and not used in the manufacture of distilled spirits are not required to be registered under this section."

Allen S. James To Warren Staff

Allen S. James has joined the sales staff of Warren Petroleum Corporation, Tulsa.

James was connected with National Petroleum News, and covered the Mid-Continent activity for this publication over a long period. His first news gathering in oil circles was with Platt's Oilgram. Later he shifted to the weekly publication.

At the time of joining Warren Petroleum Corporation, he was manager of the Mid-Continent office of the publication.

First W. P. R. A. President Dies

W. D. Richardson, first president of the Western Petroleum Refiners Association, died at Fort Worth August 3. He was buried at Quincy, Illinois, his former home. As a salesman for the oil business of his family, he came to Texas prior to the development of oil in the Corsicana field. In 1896, he returned and the Richardson-Gay refining plant was started in Corsicana.

Later he was engaged in refining in both Oklahoma and Kansas. In 1929 he returned to Texas, where he was connected with Cosden Petroleum Corporation over a period, and brought it through receivership in 1937.

California Sales Cooperative

Seven independent refining concerns in the Los Angeles basin have formed the Refinery Sales Company to handle output of the plants. Headquarters have been opened at 530 West Sixth Street. Marc D. Leh is general manager, and George Collinge is assistant.

Concerns affiliated in the cooperative effort are: McCallen Refining Company, Exter Refining Company, Mercury Petroleum Company, Harbor Refining Company, Envoy Petroleum Company, El Camino Refining and Triangle Oil & Refining Company.

Officials are M. M. McCallen, McCallen Refining Company, president; Carl von Bibra, Exter Refining Company, vice president; David E. Brown, Mercury Petroleum Corporation, secretary-treasurer. These officials and the following comprise the board of directors: H. A. McOwen, Harbor Refining Company; A. M. Lockhart, Envoy Petroleum Company; Earl G. Whitehead, El Camino Refining Company, and L. W. Frankley.

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical And Chemical Data

Boiling Points of n-Heptane and 2,2,4-trimethylpentane over the Range 100- to 1500-Millimeter Pressure, E. R. SMITH, *J. Res. Natl. Bur. Standards* **24** (1940) pp. 229-34. (Res. Paper No. 1280.)

Using a comparative dynamic method, with water as the reference standard and ebulliometers of the Swietoslawski type data were obtained from which the following equations were developed to express the relationship between temperature and vapor pressure from 100 to 1500 mm.: For n-heptane, $\log_{10}p = 6.905113 - [1269.821/(217.110 + t)]$; for 2,2,4-trimethylpentane $\log_{10}p = 6.820137 - [1262.707/(221.307 + t)]$. In these equations, p is the vapor pressure in standard millimeters of mercury of the substance at the temperature t in degrees C.

Effect of Pressure on the Enthalpy of Benzene, E. R. GILLILAND AND R. V. LUKES, *Ind. & Eng. Chem.* **32** (1940) pp. 957-62.

The purpose of the investigation was to obtain direct experimental data on the effect of pressure on the enthalpy of hydrocarbons in the critical range. In certain types of engineering design and calculations on equipment operating at elevated pressures, a knowledge of the effect of pressure on the enthalpy of the materials processed is desired. Few experimental data are available. The enthalpy change has been calculated but discrepancies appear between these calculations and the few data that do exist, particularly in the critical region. The authors describe an apparatus for measuring the isothermal enthalpy change accompanying the expansion of a vapor from an elevated pressure to atmospheric pressure. The results of such measurements are reported for benzene at pressures up to 190 atmospheres.

Octane Ratings of a Number of Pure Hydrocarbons and of Some of Their Binary Mixtures, J. SMITTENBERG, H. HOOG, B. H. MOERBEEK AND M. J. V.D. ZIJDEN, *Jour. Inst. Petr.* **26** (1940) pp. 294-303.

Since the requirement of high octane fuels for aeroplane engines is still increasing, a knowledge of the behavior in the engines of individual hydrocarbons of high octane number becomes more and more important. Reference is made to previous literature on this general subject. The investigation covered the octane numbers of fifty individual hydrocarbons, which were determined in an accurate way by the use of the standardized C.F.R.-A.S.T.M.-Motor method. Most of the hydrocarbons used were prepared synthetically. Approximately 2 kilograms of each hydrocarbon were prepared and purified by rectification. A further small quantity was highly purified for the purpose of determining the physical constants. Reference is made to a paper in which the preparation and purification of the hydrocarbons is described in detail. The method of extrapolating the octane scale below zero and above 100 is described. In the paraffin series methane is the hydrocarbon with the highest octane number. The octane numbers of the normal paraffins decrease regularly with increasing chain length. Branching of the chain increases the octane number. Among the liquid paraffin hydrocarbons there are only two that have a higher octane number than 2:2:4-trimethylpentane, namely 2:2:3-trimethylbutane and 2:2:3-trimethylpentane. The dispersion among the octane numbers of the olefins is much less than among the paraffins. Some of them, e.g., ethene, propene and some strongly branched olefins have lower octane numbers than the corresponding paraffins, whereas the octane number of others, e.g., n-pentane, n-hexene, n-octene, 3-methylheptene and others is lowered on hydrogenation. The octane numbers of the naphthenes investigated give an indication that the five-ring naphthenes may have higher octane numbers than the four- and six-ring naphthenes with the same number of carbon atoms. The octane numbers of the aromatics investigated were above 100. The reproductibility of the octane number of pure benzene was unsatisfactory; on different days it varied from 103 to 110, and the real octane number is probably much higher. The octane numbers of binary hydrocarbon mixtures were investigated, partly to verify the applied extrapolation method of the octane scale and partly to gain insight

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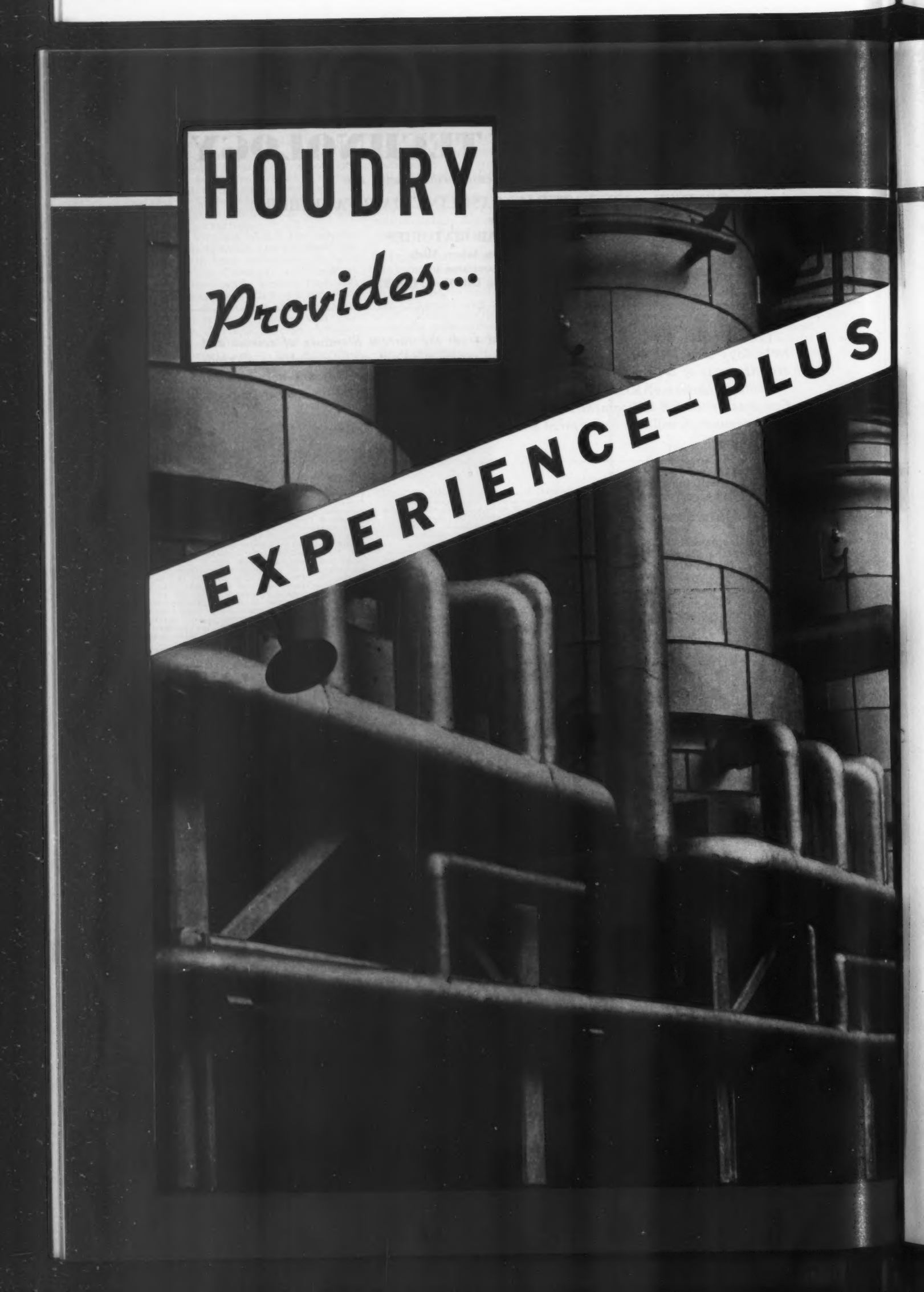
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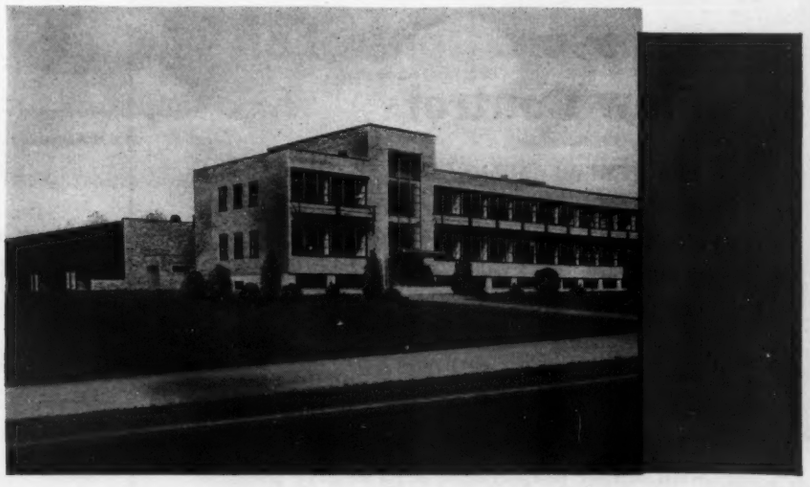

Photograph shows the new Houdry Research Laboratory consisting of Research, Physical Test, and Development buildings.

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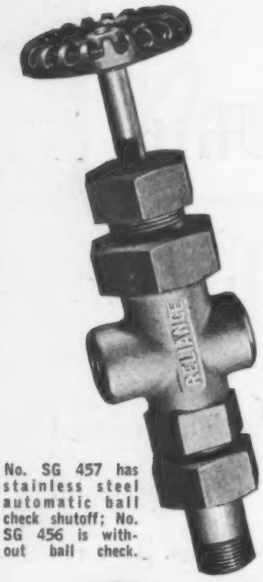

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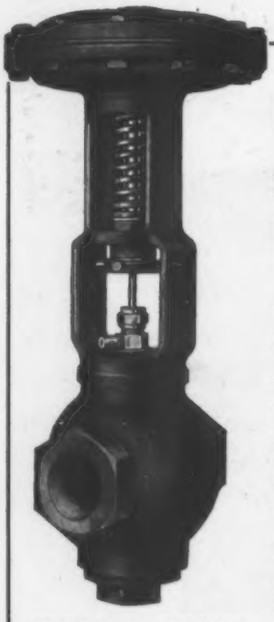

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into the blending value of the different hydrocarbons. The results are given in graphical form. A detailed table presents the physical constants of the hydrocarbons and the octane numbers found for each of them.

Phase Equilibria in Hydrocarbon Systems, B. H. SAGE AND W. N. LACEY, *Ind. & Eng. Chem.* **32** (1940) pp. 992-6.

The behavior of mixtures of propane and n-pentane has not been investigated over any extended range of compositions. Such work as has been done on this system is briefly reviewed. The apparatus and procedure used are described. The volumetric and phase behavior of nine mixtures of propane and n-pentane were investigated experimentally throughout the two-phase region at temperatures above 130° F. From these primary data the specific volume and composition of the coexisting phases of the system were established within this range of conditions. The data are presented in graphical and tabular form in some detail.

Equilibrium Cell for Investigating Properties of Fluids from Petroleum and Natural-gas Reservoirs, K. EILERTS, R. V. SMITH AND R. C. WRIGHT, U. S. Bur. Mines Rep. Invest. No. 3514, April, 1940.

A cell is described that can be used for the measurement of dew point, saturation pressure, and specific volume of hydrocarbon mixtures. The cell is designed to operate at pressures up to 5000 lbs. per sq. in. absolute and within the range of the temperature common in the production of petroleum. Although the cell was developed particularly for the study of hydrocarbon mixtures from so-called combination wells, it can be used equally well for the study of mixtures of interest to refiners.

Measurement of Viscosity in the Critical Region. Ethylene, S. G. MASON AND O. MAASS, *Can. J. Res.* **18** (1940) pp. 128-37.

An oscillating-disk viscometer of precision type was constructed with a view to studying the viscosity of systems at the critical temperature and critical pressure. A new method of computing logarithmic decrements is described, and typical results obtained with ethylene are presented. The transition in viscosity on an isochore through the critical temperature is of particular interest.

Computations of Some Physical Properties of Lubricating Oils at High Pressures, I. Density, R. B. DOW AND C. E. FINK, *J. Applied Phys.* **11** (1940) pp. 353-7.

Using the data now available on the density of fluid lubricants as a function of temperature and pressure the equation $p = p_0 (1 + ap - bp^2)t$ has been derived, where p is the density at a given gage pressure p and temperature t; p_0 is the corresponding density at atmospheric pressure. The constants a and b are tabulated for 10° intervals from 20° to 220° F. and the density equation is valid up to 50,000 lb./sq. in. pressure. Although derived from data on mineral oils, the equation is equally applicable to animal, vegetable and fish oils. The variation of density with pressure is independent of the nature of the oil.

Chemical Compositions And Reactions

Polymerization of Ethylene by Alkyl Radicals, J. C. JUNGERS AND L. M. YEDDANAPALLI, *Trans, Faraday Soc.* **36** (1940) pp. 483-93.

The yield of polymers as determined from pressure variation for the polymerization of ethylene by alkyl radicals was found to increase with ethylene pressure and to decrease with alkyl iodide pressure and light intensity. Yield decreased down the series methyl, ethyl, propyl, and iso-propyl. The light used was that from a mercury arc filtered through uviol glass. Experiments were made from 130° to 245° C. and showed some variation with temperature. Polymers are formed through bimolecular additions of ethylene to the radicals. The disappearance of the radicals results from saturation through capture of a hydrogen atom and bimolecular recombination of radicals.

The Preparation of Tertiary Acetylenes, K. N. CAMPBELL AND L. T. EBY, *Jour. Amer. Chem. Soc.* **62** (1940) pp. 1798-1800.

The catalytic reduction of acetylenes offers a good means of preparing olefins of known position of the double bond. This work so far has been confined to the straight chain com-

pounds, as acetylenes containing branches near the triple bond have been difficult to prepare and but few of them are known. In order to extend the reduction studies to this type of acetylene it therefore was necessary first to develop a method of preparing such compounds. Branched chain acetylenes have been prepared in good yields by coupling tertiary acetylenic chlorides with aliphatic Grignard reagents. Several new acetylenes have been prepared and reduced to the saturated hydrocarbons. The properties of these compounds are tabulated, and the methods of preparation described.

The Nitroparaffins, C. L. GABRIEL, *Ind. & Eng. Chem.* **32** (1940) pp. 887-92.

The large-scale production of the nitroparaffins and some of their derivatives represents a new chapter in the development of the synthetic organic chemical industry. The synthetic organic industry was born about the middle of the nineteenth century and was largely developed around the aromatic hydrocarbons. This new development, therefore, in which paraffins are nitrated, is of peculiar interest. The products made to date are: nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane, and derivatives of these substances. Many reactions for these products are indicated in the article, although they represent only a small portion of the possible total. It is suspected that nitroparaffins with longer carbon chains will soon be available. It is evident, therefore, that these new chemicals will form the basis for industrial research for years to come, and that these products will help greatly to expand the scope of chemical manufacture.

Manufacture: Processes and Plant

English Engineering Units and Their Dimensions, E. W. COMINGS, *Ind. & Eng. Chem.* **32** (1940) pp. 984-7.

Three different consistent systems of English units are in use, in each of which length is expressed in feet, and time in seconds These are: the absolute system, the gravitational system, and the engineering system, widely used in chemical engineering. The purpose of the paper is to clarify the problems arising from the use of these three systems, and to indicate the relation between them without advocating the exclusive use of any one. The quantities and their dimensions in the three systems are given, units are defined, samples are given of the use of dimensions, and of the application of the unit to specific problems.

A Study of Plate Efficiency in Fractionating Columns. II., F. RUMFORD, *J. Roy. Tech. Coll.* (Glasgow) **4** (1940) pp. 650-9.

The entrainment of liquid in a fractionating column is caused by foaming, by carriage of small drops in the upward stream of vapor and by the upward projection of drops caused by the bursting of bubbles at the liquid surface. The last is the most important cause of entrainment if foaming is not occurring It was found that changes in the surface tension of the liquid had no appreciable effect on the projection of drops from the bursting bubbles. Experiments were conducted with a sodium chloride solution and surface tension agents such as sulfonated Lorol, Perminal W, and an anti-foaming agent Siotol C.

Multicomponent Distillation Problems, H. J. HIBSHMAN, *Ind. & Eng. Chem.* **32** (1940) pp. 988-91.

The author briefly reviews the methods that have been proposed for the solution of multicomponent distillation problems. The single equilibrium line method proposed is a graphical one that uses a Cox vapor pressure chart on a transparent sheet as equilibrium lines. Any number of problems involving any or all of the same components can be solved by superposition of the chart on the appropriate operating lines. The method reduces appreciably the time required to solve these problems. The method was checked by the solution of several problems that had been solved by other methods. The solutions obtained were approximately identical with those obtained by the other methods. The procedure is explained in detail in its application to a problem of separating benzene, toluene and metaxylene.

Multicomponent Rectification, E. R. GILLILAND, *Ind. & Eng. Chem.* **32** (1940) pp. 918-20.

In designing rectification equipment for the continuous separation of the components of a solution, the engineer is confronted with the problem of determining the plate on which the feed solution should be introduced. The composition of the fluid on the feed plate that gives the fewest number of plates is termed the optimum feed-plate composition. The criterion of this composition is pre-

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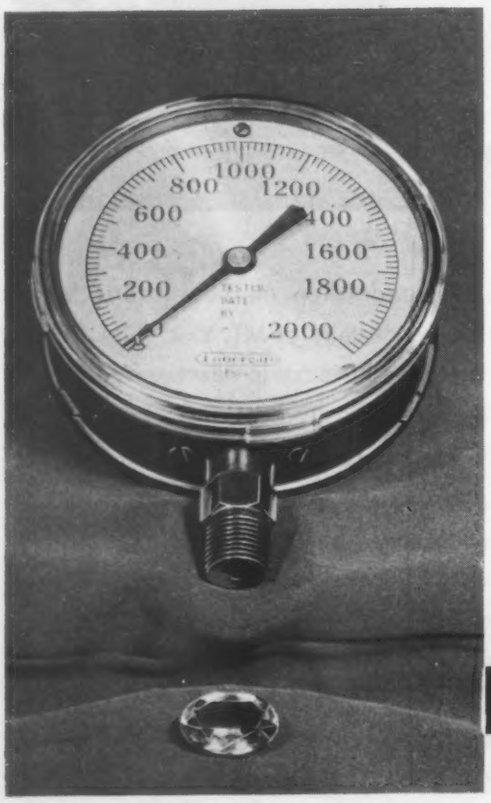

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sented. The composition of the liquid on the feed plate that gives the fewest plates for the separation is considered for three different types of feed tray action. Approximate equations are developed for these three cases, and these can be used to estimate the optimum feed-plate composition.

A New Heat Transfer Medium for High Temperatures, W. E. KIRST, W. M. NAGLE AND J. B. CASTNER, *Chem. & Met. Engr.* **47** (1940) pp. 472-5.

Heat transfer media for high temperatures have always presented a serious problem, particularly in the petroleum industry where high temperatures and extensive heat exchange are involved. Dowtherm, hot oil and mercury have been used for many years, and, within certain limitations, have been satisfactory. However, there are some uses for which these materials are not suited. A new heat transfer medium, a mixture of inorganic salts known as HTS, has been developed to fill some of these gaps. This mixture, which consists of approximately 40 percent of sodium nitrite, 7 percent sodium nitrate, and 53 percent of potassium nitrate, by weight, has been adopted because of its low melting point, high heat transfer rate, thermal stability, and lack of corrosive action on steel at temperatures above those obtainable with other heat transfer media. The first extensive use of this material has been in the Houdry catalytic cracking process. The properties of HTS are given, as well as the heat transfer coefficients obtainable in the use of this material. The results of corrosion tests are given. Extensive tests were made on the explosibility of HTS in the presence of organic materials. Precautions to be observed in the use of the material are discussed.

Heat Insulation on Cylindrical Surfaces, C. TURNER, *Ind. & Eng. Chem.* **32** (1940) pp. 904-7.

In the design of insulation for pipes and cylindrical surfaces, it is not only necessary to consider the conductivity of the insulating material for the mean temperature of service, but also the relative effectiveness of the covering as a result of its individual proportions. The effectiveness decreases with decreased radius of curvature and increased thickness of insulation. On high-temperature equipment of small diameter, the effect of curvature or shape of insulation is often most important. The purpose of the paper is to present a table or chart by which the approximately true insulating effect of coverings on piping or other cylindrical vessels can be determined quickly. This is done by correlation of the relative effectiveness of insulation with its thickness and radius of curvature, as defined by the ratio of diameter of cylinder to diameter of insulation.

Action of Solutizers in Mercaptan Extraction, D. L. YABROFF AND E. R. WHITE, *Ind. & Eng. Chem.* **32** (1940) pp. 950-3.

Aqueous caustic solutions containing certain organic solvents or organic salts ("solutizers") are much better than straight aqueous caustic solutions for the extraction of mercaptans from gasolines. A study of the action of solutizers shows that, as expected from previous work, organic solvent solutizers increase the solubility of unneutralized mercaptan in the alkaline phase and thereby lead to more complete mercaptan removal from the oil phase. Organic salt solutizers, in the other hand, exert a salting-out effect on the unneutralized mercaptan at low solutizer concentrations. This effect is reversed at higher solutizer concentrations. In addition, both types of solutizers appear to eliminate in the main the marked salting-out effect of the sodium hydroxide itself which is observed with unsolutized caustic solutions. The mercaptans studied range from ethyl to heptyl mercaptans. The data are presented in tabular and graphical form in some detail.

New Trends in Boiler Feedwater Treatment, F. G. STRAUB, *Chem. & Met. Engr.* **47** (1940) pp. 477-9.

Modern designs for steam production have placed increased responsibilities on engineers in charge of feedwater treatment; higher steam pressures, increased heat transfer rates and other trends have resulted in special problems and have required the development of new methods of treatment. The author reviews the latest developments as pertaining to the problems of scale formation, corrosion, embrittlement, and carryover. The recirculation of sludge with increased rate of softening in the cold process lime softener has resulted in the wider application of this type of softener as a primary treatment ahead of zeolite and hot process softeners. The modification of the zeolite method of softening so as to use the hydrogen as well as the sodium cycles has given a new method of elimination of the positive and in some cases the negative ions from water. New base exchange softener materials are low in silica, whereas the older type of zeolite had a high silica content. The use of these materials thus prevents the contamination of the treated water

by the silica. The hydrogen cycle has proved quite effective in removing the ammonium compounds from water. One of these methods removed all of the hardness, and additional chemical treatment is often essential to prevent scale formation. The most common method in use is the use of phosphate for the prevention of sulfate or carbonate scale. The subjects of corrosion, embrittlement and carryover are each briefly discussed.

Utilization of Natural Gas for Chemical Products, H. M. SMITH, U. S. Bur. Mines, Inf. Circ. No. 7108, April, 1940.

The manufacture of chemical products from natural gas was retarded for a long time through the prevalent belief that the hydrocarbons composing the gas were too non-reactive for use. Recent research has shown, however, that these hydrocarbons will react when activated by the effects of heat, pressure, chemical reagents and light, and that good yields of useful products can be obtained. The Circular includes ten charts with relevant annotation, giving the essentials of the manufacture of chemical products from natural gas. Charts VI to IX trace the development of chemical syntheses from primary products obtained by methods of hydrocarbon conversion previously described, i.e., decomposition, oxidation, halogenation, and nitration. Chart X gives consideration to the uses of non-hydrocarbon components of natural gas. Some of these, such as helium, are valuable. Others, such as hydrogen sulfide, are objectionable. Some natural gases are composed almost entirely of carbon dioxide which can be utilized.

Products: Properties and Utilization

Characteristics of Diesel Fuels Influencing Power and Economy, A. J. BLACKWOOD AND G. H. CLOUD, *J. Soc. aut. Engrs.* **46** (1940) pp. 49-53.

The authors present the results of an extensive fuels research program dealing with power and fuel economy obtained when using Diesel fuels of varying physical and chemical characteristics. Several gas oils from widely different typical crudes were fractionated into four cuts of approximately 100° F. boiling range. In all, thirty fuels were so provided. Most of the tests were run by use of a 6-cylinder, 3¼ x 4½ ante-chamber engine. Tests with fuels of varying mid-boiling points but having the same cetane number show that fuel economy improves with increasing mid-boiling point. Since all tests were run on a volume basis this may be occasioned by an increase in the number of B.t.u.'s per gallon. As speed increased from 800 to 2400 r.p.m. the effect of cetane number was gradually reversed, the lower-ignition-quality fuels showing the best volumetric economy at lower speeds, and the higher-ignition fuels better at higher speeds. As speed increases ignition lag becomes more significant, and consumption deviates from the heat content basis in favor of cetane number, whereas at lower speeds ignition lag is of less importance. Assuming complete combustion, fuel volatility affects the specific volumetric consumption only insofar as it is related to heating value and ignition quality. A chart shows the cross-relationship between heating value, ignition quality, and viscosity with other fuel properties commonly available from routine fuel inspections.

Rheological Properties of Asphaltic Bitumens, R. N. J. SAAL AND J. W. A. LABOUT, *J. Phys. Chem.* **44** (1940) pp. 149-165.

Mathematical analyses of five types of rheological measurements on mixed gel-sol type systems are given. These include deformation under constant shearing stress, recovery, relaxation of internal stress, recovery after partial relaxation of the stress, and relaxation of internal stress after partial recovery. Measurements on two asphaltic bitumens of different types are found to be in satisfactory agreement with theory. The data are considered to support the theory that such bitumens are mixed gel-sol systems.

Lubricants and Lubrication, J. I. CLOWER, pp. VIII + 464. McGraw-Hill Publishing Co., Ltd., London. 1939. Price 33s.

The author shows himself to be possessed of a wide knowledge, both of the chemical and physical sides of the study of lubricants, and the engineering details concerned with lubrication itself. The first three chapters of the book deal with the subjects of the source, production and refining of petroleum and its products. Methods of testing of lubricants are considered, but more attention has been given to the significance of the tests than to their details. The mechanical testing of lubricants with the Almen, Timken, and S.A.E. machines, as well as the Herschel instrument, is described. It is emphasized that these tests are capable of evaluating lubricants only in terms of wear, scuffing, seizure, and possibly film strength. In the chapters dealing with

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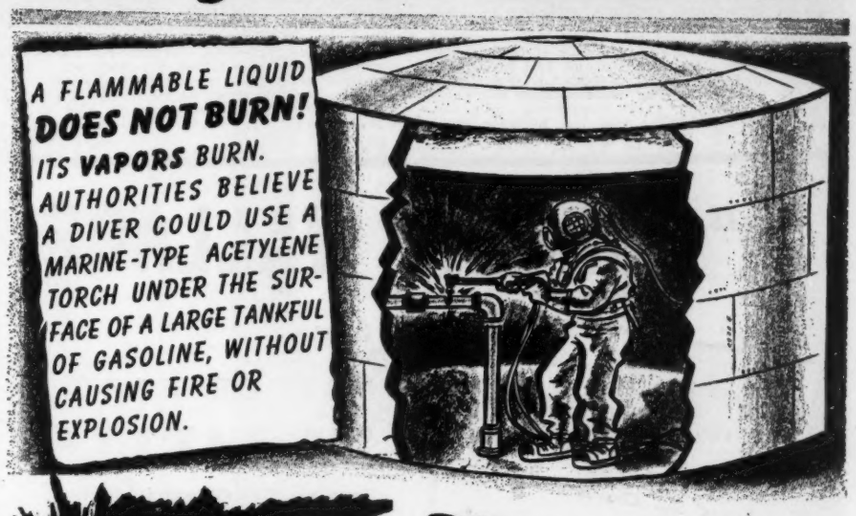
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the fundamentals of lubrication, friction between moving parts, viscosity and shear, are explained clearly. The accepted conception of oil-film formation and film rupture are described in detail. Some discussion of the lubrication of ball and roller bearings is given. Of some importance to the user of oil in bulk are oil purification and storage and handling, which subjects are treated. In describing means for recovering lubricating oils the reader is warned that lubricating oils become unfit for further use, not because they "wear out" or lose their lubricating properties, but because they undergo chemical and physical changes that may be accelerated through catalysis. Appliances used for oiling and greasing are considered, ranging from the simple oil-cup and grease-gun to the more complicated equipment for the lubrication of machinery. In the latter chapters are found descriptions of the arrangement and construction of steam engines and turbines, internal-combustion engines, compressors and refrigeration machinery, as well as the lubricating problems arising with such equipment. Diagrams and drawings are well prepared, and the printing and arrangement of the book are good.

Determination of Unsaturation in Aliphatic Hydrocarbon Mixtures, by Bromine Absorption, J. B. LEWIS AND R. B. BRADSTREET, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 387-90.

A method for the determination of the unsaturated content of petroleum fractions is briefly reviewed. A modified and time-saving bromide-bromate titration for the determination of unsaturates is described. The modified procedure eliminates a trial titration and the necessity for cooling the sample prior to titration. The method is applicable to straight-chain olefins, diisobutylene, and other branched-chain olefins of low molecular weight. With highly branched polymers, the method gives erratic results. Some sulfur compounds that affect the bromine number have been investigated, and catalysts were found that minimized the harmful effects of these sulfur compounds on the bromine number determination.

Micro-Carius Halogen and Sulfur Determination, J. B. NIEDERL, H. BAUM, J. S. MCCOY AND J. A. KUCK, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 428-31.

Through suitable combination of several favorable factors it was possible to unify, standardize, and improve the prevalent micro-Carius methods for sulfur and halogen to such an extent that one apparatus and one method of digestion, as well as an identical filtration procedure, can be applied to the determination of both types of elements. Some of the difficulties inherent in the micro-Carius method have been partially or totally remedied. The danger of explosion is practically eliminated by reducing the amount of concentrated nitric acid and by shortening the period of digestion from 5 hours to ½ hour. The apparatus and procedure are described in some detail, and typical results are given.

The Analysis and Testing of Lubricating Greases, M. W. WEBBER, *Jour. Inst. Petr.* **26** (1940) pp. 273-93.

This paper, before the Institute of Petroleum, was invited with the intention of producing a discussion upon the possibilities of standardizing tests for grease. Among the subjects covered are: soap base and content, mineral oil content, free acid and alkali, water content, unsaponified fat, ash content, impurities, fillers, addition agents, such as chlorinated waxes and sulphurized oils, rubber latex and polymerized products, corrosion, melting point, consistency, stability at high temperatures, stability at normal working temperatures, stability at high pressures, stability on storage, load-carrying capacity, low temperature efficiency. Tests in connection with each of these items are described, and are briefly discussed. Nine pages of discussion are included at the end of the paper, covering various points raised by members of the Institute.

An Asphalt Gloss and Stain Meter, A. P. ANDERSON AND T. E. REAMER, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 423-4.

The gloss of an asphalt and its tendency to stain surrounding absorbent material are two properties that have been evaluated by visual observation. A dull surface may be an indication of the presence of excessive wax, which often results in lowered ductility, decreased weathering stability, and poor adhesive properties. The tendency of asphalt, and particularly roofing asphalt, to stain surrounding material is detrimental to the appearance of the finished roof. A photoelectric device is described that permits a quantitative determination of the gloss of asphaltic bitumen. A procedure for determining quantitatively the degree to which asphalts stain absorbent materials is outlined. The apparatus is described, and typical results are given.

The Control of Bituminous Road Materials by Analysis, G. H. FUIDGE AND R. PRESTON, *Jour. Soc. Chem. Ind.* **59** (1940) pp. 108-14.

The authors describe the application of analysis in checking the composition of bituminous mixtures for road surface construction. Examples are given to show the value of analysis in indicating inefficiency in process control and in locating faults in plant, and it is shown that when careful control is exercised, compliance with specification is easily obtained. Periodic overhauling and renovation of the mixing plant for maintaining its efficiency are advised as sound economy. In order to give full effect to this policy the more frequent use of analysis is recommended to surveyors and road engineers. Typical results of variation in composition of bituminous mixtures are given. Results of determining moisture, aggregate grading, filler, and binder contents are included.

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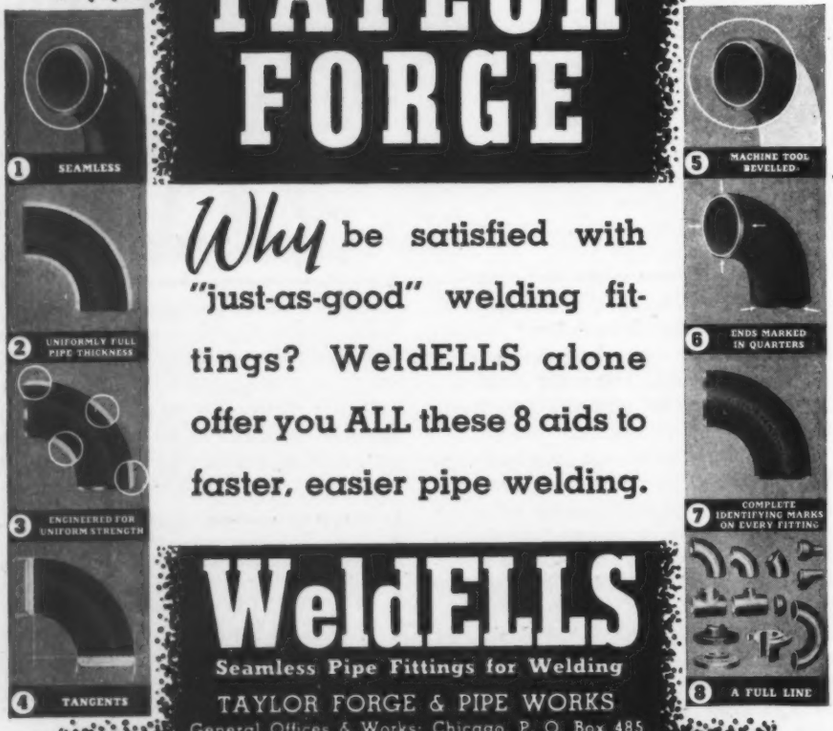
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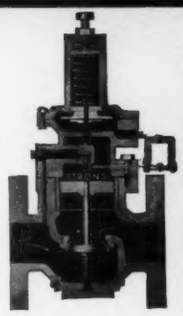

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A threading machine, designed to handle special threading operations in which extremely close tolerances for concentricity must be maintained between the thread and the body of the work, has been announced by Landis Machine Company, Waynesboro, Pennsylvania. Provision is made for supporting work between centers, facilitating grinding operations.

The machine employs a face plate on the machine spindle supplanting the usual die head, a carriage front on which the die head is mounted, and an adjustable tail stock which also supports a center.

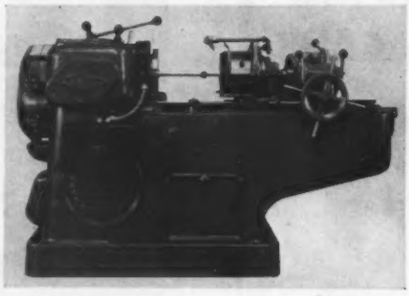
The face plate, which incorporates a live center, is employed in the same manner as the face plate on a grinding machine or lathe—to drive the work with the use of a dog.

The carriage supports the die head, which is, in this case, used as a stationary-type head. Provision is made for opening and closing the die head with a yoke.

The adjustable tailstock is clamped into position on ways located on the side of the machine bed, of sufficient length to permit handling work ranging from 2 to 16 inches long.

The tailstock center is advanced to or withdrawn from the work by a lever on the top of the tailstock. The movement of the center is actuated by means of a rack and pinion gear. The center can be clamped rigidly into position by means of a clamping lever, also located on top of the tailstock.

The machine is of the lead-screw type. The thread is generated by revolving the work between centers, the die head being propelled onto the work



Landmaco Threading Machine

and the thread lead being controlled by means of the leadscrew.

Since the work is turned, threaded and later ground between centers, a high degree of concentricity can be maintained between the thread and the body of the work.

Swing Joint

PATTERSON-BALLAGH CORPORATION

A new swing joint, rated for handling steam pressures up to 100 pounds and featuring a sealing unit with a rubber gasket containing a small amount of finely divided metallic lead milled directly into the rubber, has been announced by Patterson-Ballagh Corporation, 1900 East 65 Street, Los Angeles.

The lead serves as a lubricant to facilitate turning the joint, and the gasket expands slightly with heat to help maintain a perfect seal.

The joint is made of heavy bronze, weighs 4½ pounds, and is available in the ¾-inch straight style.

Controller

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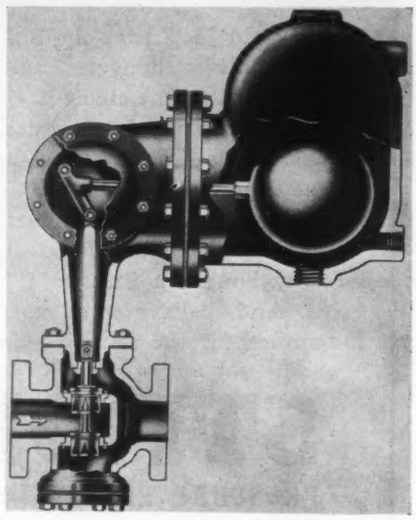
A new control unit, designed for use as a liquid-level controller or, by mounting the float higher than the valve discs, as a drainer or super-



Kieley & Mueller's Controller

capacity trap, has been announced by Kieley & Mueller, Inc., 40 West Thirteenth Street, New York.

The device, designated Unitrol, is self-contained with no stuffing box connections. It is constructed in semi-steel in pressures up to 250 pounds, in cast steel up to series 60, and in sizes up to 4-inch. The float is 8-inch, and V-port discs are provided in standard models.

Dilatometer

THE BRISTOL COMPANY

A new dilatometer has been announced by The Bristol Company, Waterbury, Connecticut. Designated Model RB, it is a direct reading dilatometer which both indicates and makes an ink record of time-dilation and temperature-dilation changes simultaneously during heating and cooling cycles of ferrous and non-ferrous metals, ceramics and other materials of rigid form.

Waste Reclaimer

GALE OIL SEPARATOR COMPANY

A waste reclaimer and conditioner, designed for gravity operation without moving parts and for removing liquid or solid particles from liquid waste, has been introduced by Gale Oil Separator Company, Chrysler Building, New York.

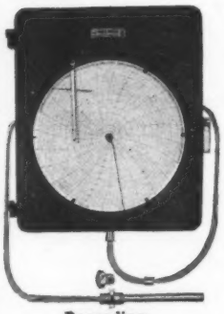
It is constructed to permit flowing the liquid mixture to be treated beneath a quiescent body of fluid, with the continual submergence causing the breaking up of the mixture so that the lighter liquids, separated oils and oily or other substances automatically rise to the surface.

The conditioner can be cleaned while operating by means of a clean-out pipe at the bottom beneath the outlet pipe. A draw-off valve is adjustable to re-

SILENT TESTIMONY

A steady flow of orders for good reliable PALMER Thermometers is mute evidence of the confidence in these instruments.

Palmer Recording and Dial Thermometers as well as Palmer "Red-Reading-Mercury" Industrial Thermometers are tried and tested before being offered to the industry. They perform satisfactorily for many customers so why not fall in line for Quality Thermometers at satisfactory prices.



Recording Thermometer

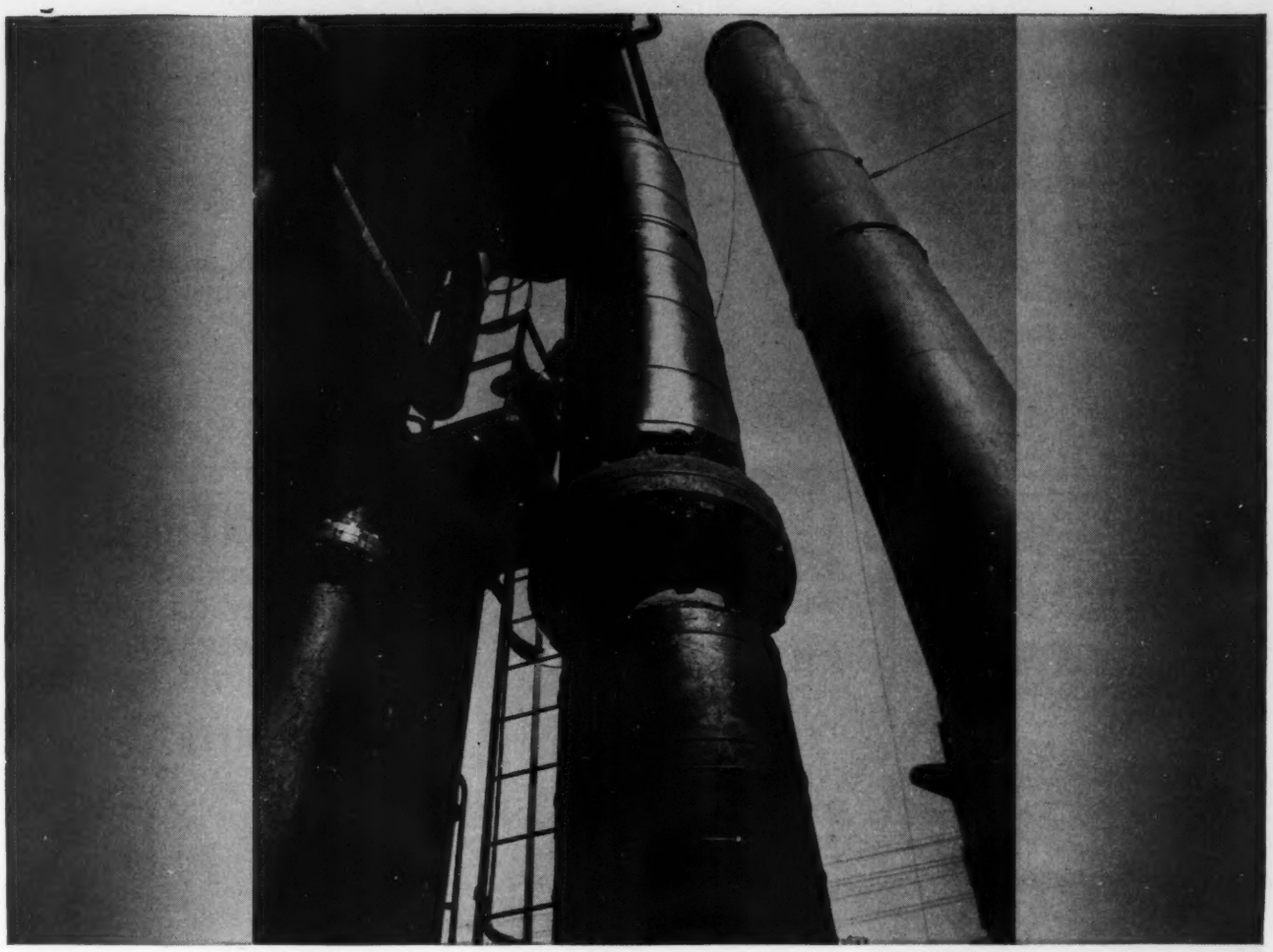
Dial Thermometer

(Write for No. 300-D or 200-E catalogs . . . new editions)

THE PALMER CO.

Manufacturers—Indicating, Recording, Dial Thermometers

2511 NORWOOD AVE., CINCINNATI NORWOOD, OHIO
King & George Sts., Toronto, Canada



IT'S SERVICE CAPACITY—FIRST, LAST AND ALL THE TIME

Changing practice in refinery operation has resulted in putting a progressively greater burden on accessory equipment of many kinds. So it has become increasingly important to operating economy to specify materials on the basis of service capacity first, last and all the time.

Pipe is no exception. For example, comparatively high temperatures coupled with corrosive materials make special demands. And it has been demonstrated that Chromium-Molybdenum (4–6% Cr.) steel measures up to the service and economic requirements.

This steel meets A.S.T.M. Specification A 158-38-T for elevated temperature piping. In addition it has other qualities, such as good creep strength, good corrosion resistance and practical freedom from temper brittleness, that add to its service ability.

Complete data on Chromium-Molybdenum and other heat-resisting Molybdenum steels for refinery use will be found in Section 8 of our technical book, "Molybdenum in Steel". Either the complete book or the individual section will be sent free on request to interested executives or engineers.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

ESPECIALLY RECOMMENDED FOR USE IN THE

COPPER SWEETENING PROCESS

Nichols

TRIANGLE BRAND

COPPER SULPHATE

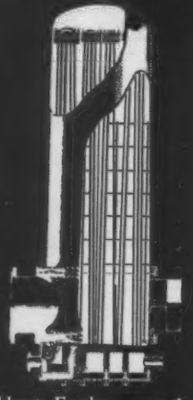
is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99% PURE

Quotation on request, on any quantity required. Prompt shipments can be made from our nearest plant.

PHELPS DODGE REFINING CORP.
40 WALL STREET, NEW YORK
230 N. MICH. AVE., CHICAGO

LEACH
FRACTO
CONDENSERS
for High Pressure and Temperature.

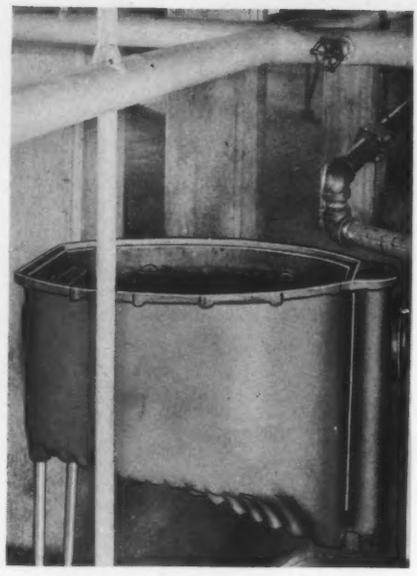


Also Heat Exchangers for Vacuum and Atmospheric Service.

Fracto Control

Patented in the United States and Foreign Countries.

C. H. LEACH CO., Inc.
117 Liberty Street, New York, N. Y.



Gale Conditioner

claim oils, oily substances or greases. It is available in 9 standard sizes from 18 to 1500 gallons per minute, and larger units are built on specification. Construction is of either sheet steel with cast iron rugae bottom, or entirely of cast iron.

Meter

PITTSBURGH EQUITABLE METER COMPANY

A meter developed for measurement of liquefied petroleum gases, featuring a cast iron outer case to provide safety in measurement of highly volatile vapors, has been announced by Pittsburgh Equitable Meter Company, 400 North Lexington Avenue, Pittsburgh.

The meter features two relatively short sealing surfaces, effecting a seal by use of surface grinding and large-diameter screws. The index housing within the meter cover is without a stuffing box to seal the index shaft, a solderable, thick, high-strength glass providing a seal on the housing.

Emsco Meter

The drive shaft is mounted with its drive gear in an integrally designed movement box, providing a lubricated seal to prevent escape of gas should the index glass be broken. Diaphragms of special material described as particularly resistant to action of liquid hydrocarbons, or sheepskin treated to resist such action, are furnished.

Indexes reading in therms, decitherms, gallons, pounds or equivalent cubic feet are available on specification of the user.

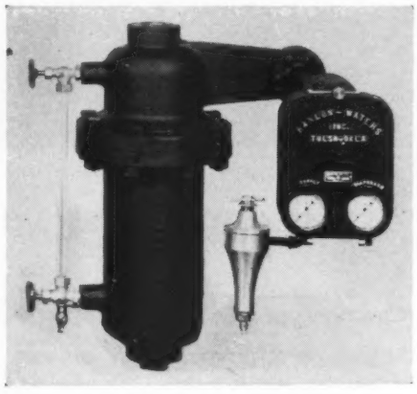
Welding Regulators

LINDE AIR PRODUCTS COMPANY

Addition of three new single-stage general service regulators to its line of Oxweld welding and cutting apparatus has been announced by Linde Air Products Company, 30 East 42nd Street, New York. Oxweld R-80 regulator is for delivery of oxygen at working pressures

For CONTROL of
LIQUIDS
OF ANY GRAVITY,
TEMPERATURE
OR WORKING PRESSURE

HANLON-WATERS Type 850
LEVEL CONTROLLER



The ONLY Level Controller with:

NO STUFFING BOX
NO LEAKAGE
NO FRICTION

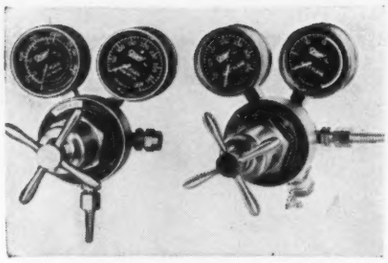
Why is H-W Type 850 the BEST Liquid Level Control on the Market?

• ASK THE MEN WHO OPERATE THEM — THEY ARE OUR BEST SALESMEN!

H-W TYPE 850 IS SATISFACTORILY HANDLING PROBLEMS THAT WERE CONSIDERED IMPOSSIBLE

Complete information and prices available at your nearest HANLON-WATERS Branch.

HANLON-WATERS, INC.
TULSA, OKLAHOMA
Chicago, Pittsburgh, Philadelphia, St. Louis, Denver; Shreveport and Lafayette, La.; Fort Worth, Houston, Corpus Christi, Longview and Odessa, Texas.



Oxweld R-80 and R-81 Regulators

up to 200 pounds per square inch, Oxweld R-81 is its companion acetylene regulator, and Oxweld R-82 is a fuel gas regulator.

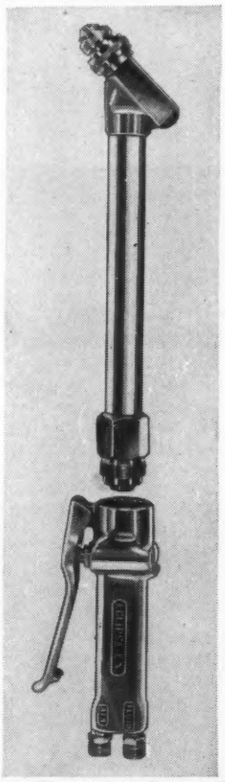
Types R-80 and R-81 are of the stem type, with the valve closing with the incoming pressure to assure positive seating action. Type R-82, also of the stem type, may be used with various gases, including propane and butane.

The regulators are designed for all welding, cutting and deseaming operations where simplicity of construction and large capacity are demanded.

Spray Gun

ECLIPSE AIR BRUSH COMPANY

An extension spray gun, type EX, designed for painting large surfaces beyond the natural reach of the operator without use of scaffolding and staging, has been announced by Eclipse Air Brush Company, 390 Park Avenue, Newark, New Jersey. It is supplied in lengths up to 12 feet.



Eclipse Extension Spray Gun

The extension has a detachable gun grip control, and different lengths of shaft can be used in the same grip. The shaft turns in the grip so the spray may be in any direction. The spray head is supplied in either of two standard models to provide proper application of different types of materials.

Oil Immersion Heaters

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Two improved types of oil immersion heaters designed specifically for heating mineral oil, paraffin and alkaline cleaning solutions, have been announced by Westinghouse Electric & Manufacturing Company, Mansfield, Ohio. Terminal boxes on the heaters have been changed to condulet boxes to simplify the wiring problem.

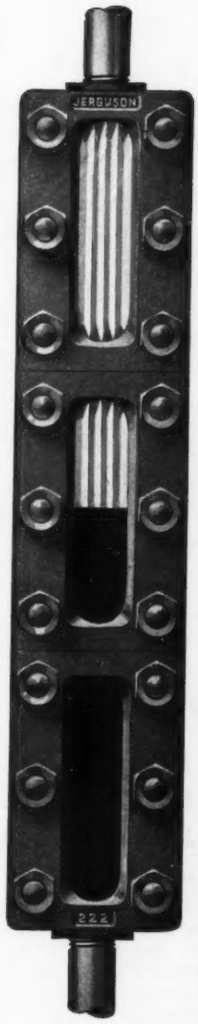
The non-circulating heater is designed for tanks or oil baths requiring little or no circulation. Heating tubes range from 14 to 37 inches in length with a rating of from 1 to 3 kilowatts. These units meet conditions where the heavy oils or minerals cannot be circulated at low temperatures because they absorb heat slowly and require a low watt-density rating.

The circulating heater is designed for applications where the oil circulates at a sufficient rate to absorb the heat and prevent excess heater tube temperatures. The heater tubes range from 32½ to 37 inches in length with a rating of from 5 to 8 kilowatts.

Pump

MILTON ROY PUMPS

An opposed-type duplex chemical pump with a rated capacity of 4 gallons an hour against a pressure of 3000 pounds has been announced by Milton Roy Pumps, 3160 Kensington Avenue, Philadelphia. A one-horsepower explosion-proof geared motor and the pump are an integral unit, and the pump has



What LIQUID?
What PRESSURE?
What VARIATION?

We shall be glad to have complete information regarding your

Gage Problems

in order that we may supply you with the best data and prices obtainable on the

JERGUSON

Gage or Gages we will very likely propose to furnish. There usually is a Jerguson for even the most severe requirements, whether the liquid is gasoline, kerosene, oil, water, or any other—whether it is a tank, tower, still, or boiler—whether the pressure is high or low—and whether the liquid is transparent or black.

At the left, for instance, is shown our REFLEX TYPE which shows the liquid as BLACK no matter what its color, while the empty space above shows WHITE.

See pages 178 and 179 of the latest Composite Refinery Catalog for Jerguson's principal products. For many refinery purposes gages can be selected directly from that catalog.

FILL IN AND MAIL YOU WILL HEAR FROM US PROMPTLY

JERGUSON GAGE & VALVE CO.,
87 Fellsway, Somerville, Mass.

Without obligating us in any way we shall be glad to have your suggestions regarding_____ *(give number)* gages for handling_____ *(oil, gasoline, etc.)* at_____ lb. per sq. in. Liquid level varies_____ inches, and gage should be at least_____ inches high. Without climbing, attendant will be_____ ft. away from the gage. The color of the liquid is_____ *(clear, red, etc.)*.

☐ Please send catalog. ☐ Please send representative.

REMARKS_____

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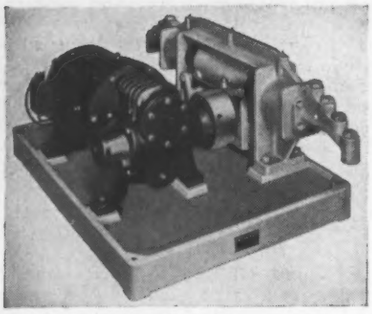


Milton Roy's Duplex Chemical Pump

double-ball check-valve construction for both suction and discharge chambers.

The unit is designed to eliminate air-binding and to automatically discharge small particles of dirt to make the pump self-cleaning. Pump plungers, ball checks and ball seats are of stainless steel.

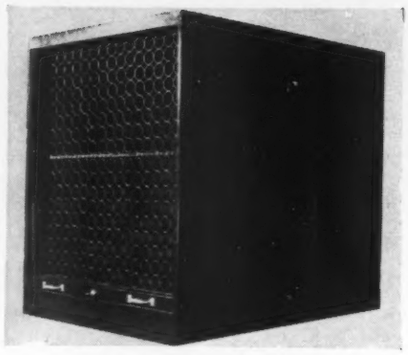
The pumps are furnished to pump against pressures up to 20,000 pounds and are intended to handle alkalis, oil solutions, sulphuric acid concentrations, chlorine solutions, hydrochloric and phosphoric acids and other liquids and chemicals. They may be used for pumping two or more chemicals simultaneously, or on separate feed to two or more points of delivery.

Tube File

F. W. ROBSON AND J. A. GERSON

A tube file for tracings, films, prints, drawings and maps has been introduced by F. W. Robson and J. A. Gerson, 2939 South Cincinnati, Tulsa.

Designated Cabtoob, the cabinet is made of 22-gauge steel with a roll-a-way door equipped with a Yale lock. It provides space for 255 2-inch rolls, and is available in models 24-, 36-, 42- and 54-inch deep. Width is 32 inches and height 42 inches. An index is provided to facilitate location of material.



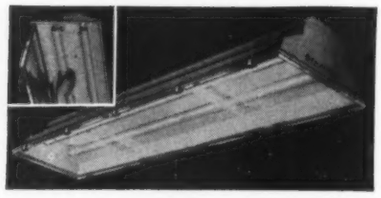
Cabtoob Tube-Filing Case

A utility model contains 255 2x54-inch filing compartments, with roll-a-way doors on each end, while a vertical model with 40 2x36-inch tubes will accommodate rolls of any length.

Fluorescent Lighting

BENJAMIN ELECTRIC MANUFACTURING COMPANY

A Fixture for fluorescent lighting featuring sealed-cover construction designed to protect the lamps and reflecting surfaces from dust and dirt and to extend the use of fluorescent lighting to locations requiring vapor-proof and dust-tight fixtures, opal glass diffusing fixtures, or unbreakable glass protection of lamps and reflecting surfaces, has been announced by Benjamin Electric Manufacturing Company, Des Plaines, Illinois.



Benjamin Electric's Sealed-Flo Unit

The unit, designed Sealed-Flo, has a cover hinged to the lamp housing and locked in place by hand-operated cover clamps. When opened, the cover hangs straight down to provide easy servicing.

It is available in arrangements for either two or three 48-inch fluorescent lamps.

Casing Bushing

DRESSER MANUFACTURING COMPANY

A casing bushing to provide a seal for the ends of a protective casing through which a pipe line runs has been announced by Dresser Manufacing Company, Bradford, Pennsylvania.

The unit consists of two halved steel rings with a rubber-compound gasket bolted between them. As bolts are tightened, the gasket expands outwardly against the inside of the casing and inwardly against outside of pipe to make a tight seal against both.

The bushing, recommended for any line where protective casing is used, is

KEEPING 'EM ROLLING **By WESTCOTT**

JOE'S METHOD . . . Cut Down Replacements by Using J-M Service Sheet

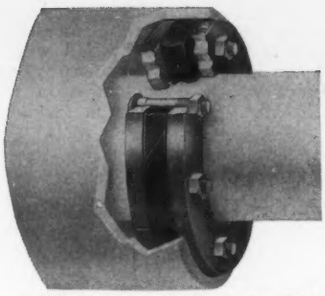
J-M SERVICE SHEET (Style No. 60). Tough, durable, resilient . . . always uniform in quality. One side graphited; the other ruled to make cutting and measuring easy.

MANY gasket failures boil down to inferior sheet packing. Most of them are as unnecessary as they are expensive. For in J-M Service Sheet, you get a dense, resilient, *uniform* asbestos material that lasts longer under practically all conditions. A tryout will show you why more and more plants are standardizing on this better sheet packing. For details on Service Sheet, and on the complete J-M line, send for the J-M Packing Catalog. Johns-Manville, 22 E. 40th St., New York, N. Y.

JM PRODUCTS

JOHNS-MANVILLE PACKINGS & GASKETS

THERE'S A DISTRIBUTOR NEAR YOU



Dresser Manufacturing's Casing Bushing

designed to seal out dirt, debris, weeds, small animals and corrosive water from the inside of the casing; to float pipe line in casing by absorbing vibration and shock from passing trains and traffic, and to center the pipe line in the casing.

Motor

THE LOUIS ALLIS COMPANY

The Louis Allis Co., Milwaukee, has announced a "Lo-Amp" electric motor that is especially designed for use on refrigerating, air-conditioning and similar installations.

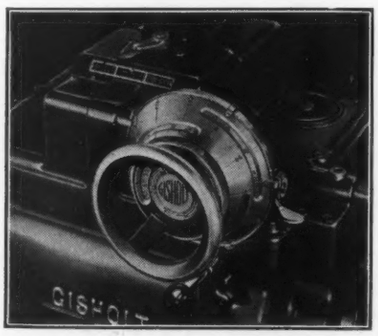
Louis Allis Motor

The motor has low locked-rotor current and can be supplied with either high-starting torque or normal-starting torque. It does not have centrifugal switches, relays, brushes or slip rings, and does not require any special control to operate.

Lathe Speed Selector

GISHOLT MACHINE COMPANY

A speed selector for use with its turret lathes, designed to reduce floor-to-floor machining time, has been announced by Gisholt Machine Company, Madison Wisconsin.



Gisholt's Lathe Speed Selector

In operation, a turn of the speed selector dial to the graduation corresponding to the diameter of the work automatically shifts the machine to the spindle speed producing the correct cutting speed for that diameter. A power-operated device, it permits selection of any of 12 available spindle speeds, and the change is accomplished without slowing down the machine.

Valves

THE ALBRIGHT EQUIPMENT COMPANY

A series of valves, designated Hydra, for use on oil, steam and water lines having pressures up to 4000 pounds, has been announced by The Albright Equipment Company, 934 Crafts Building, Pittsburgh.

The valves operate with a one-eighth turn, four stainless steel balls that close the valve engaging in port holes due to pressure on the line. There are no valve seats. The valves may be operated by

Albright Equipment Company's Hydra Valve

To Improve Cast . . .

New Fluorescent Green produces a "Pennsylvania Cast" in lube oils. It is an additive which definitely will improve the salability of your lubricants.

New Fluorescent Green:

Solubility . . . . . readily and complete
Color . . . . . unchanged by transmitted light

STABILITY:

light . . . . . fast
heat . . . . . stable
storage . . . . . stable

TESTS:

carbon residue . . . . . unchanged
fire . . . . . unchanged
flash . . . . . unchanged

Leading lube refiners in the United States and abroad have used Wilmot & Cassidy products for the past ten years. *For samples, prices, and information please write to:*

Wilmot & Cassidy, Inc.

108 Provost St. **Brooklyn, New York**

hand or by electric solenoids with push-button control.

Made in brass, bronze and steel bodies, they are available in ½-, ¾-, 1-, 1¼-, 1½- and 2-inch sizes.

Vernier-Control Variable Speed Transmission

LINK-BELT COMPANY

Announcement is made by Link-Belt Company, Philadelphia, that it is now in position to equip all sizes of the Link-Belt P.I.V. Gear variable speed transmission with vernier control, for installations where extremely fine control of speed changes is required.

This vernier control can be supplied with either one of two ratios—7½ to 1 or 30 to 1, and is equipped with two hand wheels. One is for direct control; the secondary, or vernier type control hand wheel will provide either 30 turns or 7½ turns to one of the direct wheel, depending upon which ratio of worm-gear reduction set is furnished.

Link-Belt Variable Speed Transmission

JOHN ZINK BURNERS

"HEAT-MAKERS"

Turning Gaseous and Liquid Fuels into heat. To operators of refineries the making of heat in the correct quantity in the best way is of utmost importance.

During the last eleven years John Zink and his engineers have been helping operators make heat like they want it, until today there are over 30,000 John Zink Burners making heat under gasoline plant boilers, refinery boilers, refinery stills, power boilers, and drilling boilers.

THIRTY-TWO DIFFERENT TYPES OF BURNERS

JOHN ZINK COMPANY

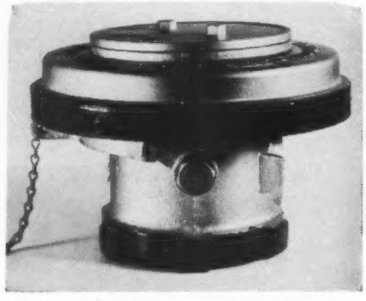
Burners • Floor Furnaces • Unit Heaters

TULSA, OKLA. NEW YORK CITY

Thief Valve

BLACK, SIVALLS & BRYSON

A series of gas-tight thief valves featuring a gasket joint designed to prevent leakage of gas even up close to the blowing pressure has been announced by Black, Sivalls & Bryson, Oklahoma City.



Black, Sivalls & Bryson's Thief Valve

The valves for relieving at intermediate pressures are available in 2-, 4-, 10- and 16-ounce rated capacities.

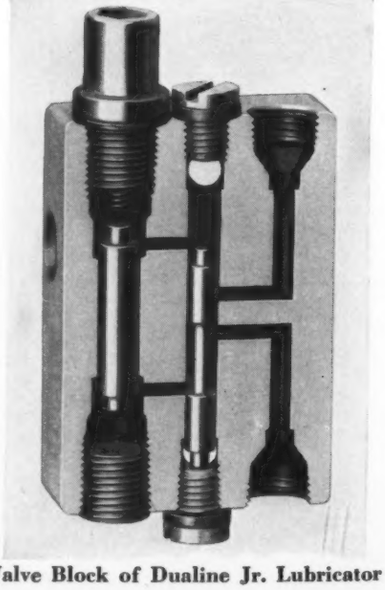
Lubricator

THE FARVAL CORPORATION

A centralized lubrication unit for use with small machine tools and other equipment, designated Dualine Jr., has been announced by The Farval Corporation, 3249 East Eightieth Street, Cleveland.

The valve of the system has two moving parts, contains no springs and no check valves, and is described as fully adjustable. It is designed to provide positive delivery of lubricant to each bearing independently of the judgment of the oiler or his ability to reach all bearings regularly.

It is supplied with a line of fittings, hose, couplings and other accessories in keeping with smaller pumps and measuring valves.



Valve Block of Dualine Jr. Lubricator